VOLUME XXX AUGUST, 1933 NUMBER 2

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

The AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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The American Journal of Roentgenology and Radium Therapy does not hold itself responsible for any statements made or opinions expressed by any contributor in any article published in its columns.

Entered as second-class matter February 10, 1930, at the postoffice at Springfield, Illinois, and Menasha, Wisconsin, under the Act of March 3, 1879. Accorded the special rate of postage provided for in paragraph 4, section 412, P.L. and R.

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OCT 16 1933

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. XXX AUGUST, 1933 No. 2

THE PINEAL BODY

ROENTGENOLOGICAL CONSIDERATIONS

By JACOB H. VASTINE, M.D.

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THE pineal body (corpus pineale), or epiphysis cerebri, is a cone-shaped body which is about 8 to 10 millimeters in length (Piersol) and rests on the dorsal aspect of the brain in the triangular pineal depression between the superior corpora quadrigemina and between the posterior ends of the two thalami. It is attached by a hollow peduncle to the roof of the third ventricle near its junction with the mid-brain and thus lies near the aqueduct of Sylvius. It is important that the roentgenologist remember its normal position that he may be better able to understand and correlate the clinical with the roentgenological findings in the diagnosis of tumors arising from this region. Examination of the brain shows that the pineal body occupies almost a central position in the skull being normally in the midline slightly posterior to the center of the anteroposterior diameter and slightly below the center of the vertical diameter. It is important to remember this rather central position that the readiness with which it is displaced by intracranial lesions may be better understood.

HISTOGENESIS

A knowledge of the embryogenesis is necessary for any serious attempt to interpret the clinical pictures presented by tumors arising from the pineal body and to correlate them with the roentgenological findings in arriving at a correct diagnosis. Globus and Silbert examined microscopically the pineal body from 9 fetuses, 18 infants, 25 children and 22 adults. At the second month of fetal life they found the pineal to consist of a dense mass of cells. This, as Bailey and Cushing state in their recent book, consists of proliferation of the medullary epithelium in one area of the roof plate to form the anlage of the pineal body. The structure of tumors arising from the pineal body frequently resembles the large undifferentiated cells described by del Rio Hortega, Krabbe, Globus and Silbert, and Bailey and Cushing. The latter authors believe that the embryonic pineal body contains neuroglial cells. This opinion is not universally accepted. Globus and Silbert found the pineal at five months to contain evidence of a primitive glandular arrangement. At birth may be seen the characteristic mosaic structure formed by groups of the small dark cells lying between masses of the larger, lighter parenchymal cells. Very large vascular channels are found at the periphery of the gland. At nine weeks after birth the mosaic nature of the structure begins to lose its definite character. At five months, there remain of the small dark

cells only a few islands, as these elements are rapidly changing into fibroblasts to form the supporting structure. At eighteen months, the parenchymal cells are grouped into alveolar arrangements by definite connective tissue trabeculae. At five and one-half years, the gland is much like the adult structure, consisting of alveoli separated by a connective tissue framework. *The only further changes are degenerative, consisting chiefly of fibrosis, hyalinization, cyst formation, and calcification.*

FUNCTION

The function of the pineal body in the human organism is still a subject of controversy. Some consider it to be a gland of internal secretion; others, a vestige of the median eye of certain reptilian forms. Descartes even suggested that it might be the seat of the soul. This, of course, is not seriously considered at the present time. Berblinger states that, in regard to the function of the pineal body, physicians are still in the stage of collecting evidence. Globus and Silbert believe that the glandular character of the pineal body cannot be disputed, at least at some stage of its development. This is particularly striking at about the sixth month of uterine life. During the early months of post-natal life, it loses this structural character and assumes a new architecture, which does not permit of functional interpretation. Thus, it would appear that the glandular function is short lived. Extensive studies by Krabbe led to similar conclusions. Tilney and Warren believe that the pineal body of the embryo contains glandular elements. Von Volkmann is of a similar opinion. Dana and Berkeley believe that the pineal body has secretory function, having to do with the processes of nutrition and growth, and that its overactivity apparently produces sexual and mental precocity. Horrax and Bailey, on the other hand, are rather skeptical with regard to the secretory structure of the pineal body; del Rio Hortega has been unable to find evidence of secretory activity of this structure.

Nomenclature. I prefer the term "pineal body" to "pineal gland" since the latter term implies glandular potentialities. Since this point is controversial it is better for the roentgenologist to employ the indifferent, non-partisan term—"pineal body."

VISUALIZATION

It has long been known by the histologist that the pineal body frequently contains calcareous deposits. This calcification, as Globus and Silbert have pointed out, is probably merely a degenerative change in the pineal body associated with fibrosis, hyalinization and cyst formation. Del Rio Hortega in a recent study of calcareous concretions in meningiomas and gliomas also rather fully discusses the calcareous changes occurring in the choroid plexus and the pineal body. The chief concern to the roentgenologist is the fact that in a majority of adults the calcareous deposits render the body opaque to the roentgen rays and therefore it casts a shadow upon the film. When this shadow was first noted by roentgenologists, it was misinterpreted as being indicative of a pathological process —probably a tumor. As technique was improved this was found to be of normal occurrence.

Frequency of visualization of the pineal body roentgenologically has been determined in several rather large series of cases with a close correspondence in the figures. Thus, Naffziger, in an examination of 215 skulls, found the pineal body to be visualized in 45 per cent of all, 15.5 per cent of the pineal bodies of patients under twenty years of age being visualized and 58 per cent in those over twenty years of age. Vastine and Kinney, in an examination of 616 cases found the pineal body to be visualized in 47.9 per cent of all cases, 19 per cent of the cases under twenty years of age being visualized, and 52.2 per cent of those over twenty years of age. Visualization of the pineal body occurred in 46 per cent of females and 58 per cent of males. Dyke, in a survey of 3,000 consecutive skull examinations, found the pin-

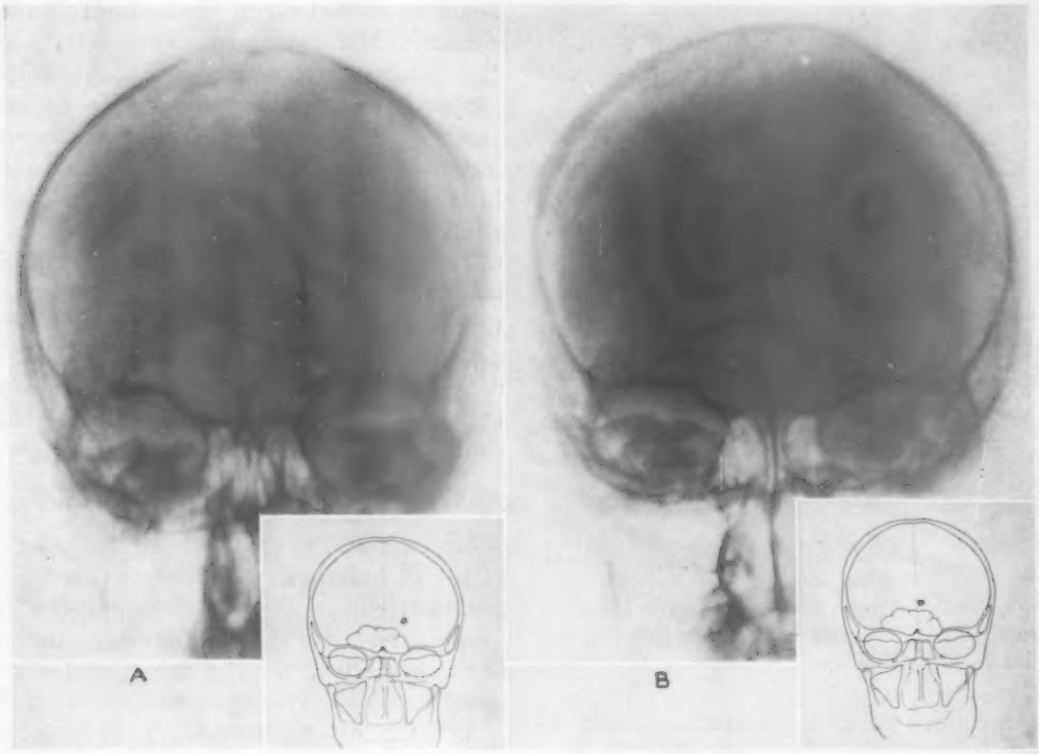

Fig. 1. A. Roentgenogram of a skull showing separation of the left lambdoidal suture, a fracture extending into the left parietal bone, and displacement of the pineal body to the right indicating the presence of an extensive intracranial hemorrhage on the left side. B. Shows an operative defect in the skull on the left side. A large subdural clot was removed at operation. Following removal of the blood clot the pineal body has returned almost to its normal position in the midline.

eal body to be visualized in 51 per cent of all cases, visualization occurring in 20 per cent of those under twenty years of age and in 59 per cent of those over twenty years of age. Of the males, 54 per cent visualization of the pineal body was found and of the females, 49 per cent. In a study of 86 cases, Beals found the pineal body to be demonstrable in 60.6 per cent of the cases, visualization being equally divided between males and females. Murphy found it visualized in over 40 of 100 consecutive cases.

The frequency of visualization of the pineal body is dependent upon the technique employed—the better the films, the more frequently the pineal body is visualized. Better average technical work is probably constantly being obtained and subsequent series of cases may be expected to show a higher frequency of visualization than those previously reported.

Visualization of the pineal body per se is of no probable significance but a visible pineal body serves as a landmark which occupies a certain normal position, and occurrence beyond this normal range in position, with certain allowance for error which will be discussed later, is indicative of intracranial pathology causing displacement. The shadow of the pineal body normally is found in the midline. Occurrence of this shadow on either side of the midline in true anteroposterior or posteroanterior films represents displacement.

DISPLACEMENT

Schüller in 1918 was the first to call attention to the value of the position of the pineal body as a diagnostic aid, and cited

Fig. 2. Section of brain of same patient as shown in Figure 1. The calcified area is seen to be in the pineal body.

an unconfirmed case of lateral displacement from contraction due to softening from an old injury. Naffziger, in 1925, added 15 cases of lateral displacement of the pineal shadow which were confirmed by operation or autopsy. Vastine and Kinney, in 1926, reported on 23 cases which were verified by operation or post-mortem examination in which the pineal body had been reported as displaced laterally. These cases consisted of frontal, temporal, and parietal lobe gliomas and meningiomas. There was lateral displacement by an acoustic neuroma and lateral displacement to the opposite side in 2 cases of intracranial hemorrhage. I have recently observed a case which illustrates the diagnotic value of lateral displacement of the pineal body (Figs. 1 and 2). The patient was admitted in an unconscious condition following a fall.

Roentgenograms of the skull showed lateral displacement of the pineal body suggesting the presence of intracranial hemorrhage. An osteoplastic flap was removed and a large blood clot was evacuated. Re-examination showed the pineal shadow to have returned almost to the midline. The case terminated fatally and the calcification was shown both microscopically and roentgenologically to be in the pineal body. These previous reports have dealt primarily with the value of lateral displacement of the pineal body from its normal midline position, in cases of tumor with displacement to the opposite side from that occupied by the tumor, in the presence of recent hemorrhage with displacement to the opposite side and in cases of atrophy due to previous trauma (Schüller), the displacement being by traction toward the side of atrophy.

Anteroposterior and Vertical Displacement

Schüller stated that the normal position of the pineal shadow in lateral roentgenograms of the skull was 1 cm. above a line joining the external auditory meatus and the lower border of the orbit, and 1 cm. posterior to the vertical plane, through the external auditory meatus. This range in position has not proved adequate in my rather limited experience. Naffziger, in 1925, said, "It is hoped that further observation and study may enable us so to standardize the lateral roentgenograms of the skull that we can detect an anterior or posterior or an up and down deviation of the shadow from its normal position." In 1926, Vastine and Kinney, working under the guidance of Sosman, at the Peter Bent

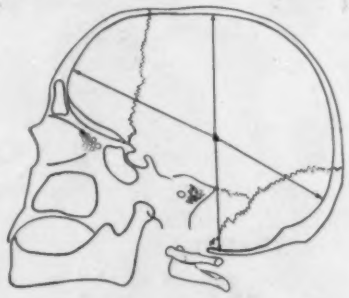

Fig. 3. Measurements are taken from the pineal body to: (1) the inner table of the frontal bone at its most distant point; (2) the inner table of the occiput at its most distant point; (3) the inner table of the vault; (4) the level of the base of the skull.

Brigham Hospital, in a series of 200 skull films showing calcification of the pineal body which were essentially negative for intracranial lesions attempted to establish a normal range in position on the lateral films of the skull.

Measurements were taken, as shown in Figure 3, from the pineal body to:

1. The inner table of the frontal bone at its most distant point.
2. The inner table of the occiput at its most distant point.
3. The inner table of the vault.
4. The level of the base of the skull.

In Chart 1, the measurement of the distance from the pineal body to the inner table of the frontal bone was plotted against the sum of the distances from the pineal shadow to the frontal bone and to the occiput—this sum is approximately equal to the greatest anteroposterior diameter of the skull. The pineal bodies of normal skulls were found to lie between the lines *a-a'* and *b-b'* which we considered the normal anteroposterior variation in position.

In Chart 2, the measurement from the pineal body to the inner table of the vault was plotted against the sum of the distances from the pineal body to the inner table of the vault and to the level of the base of the skull—this sum is approximately equal to the vertical diameter of the skull. The pineal bodies of normal skulls were found to be between the line of *c-c'* and *d-d'* which we considered the normal vertical variation in position.

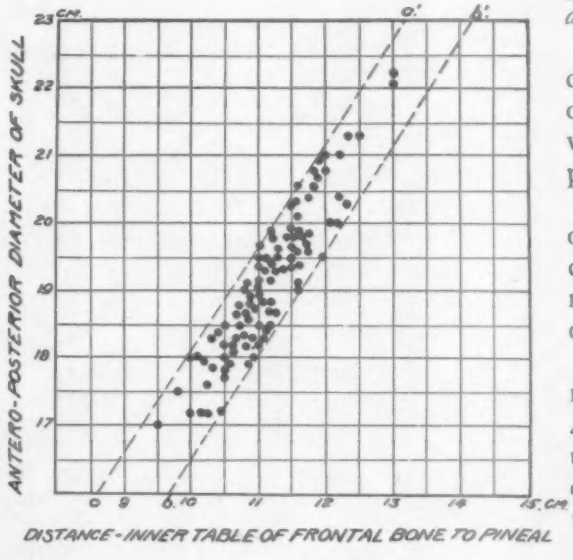

Chart 1.

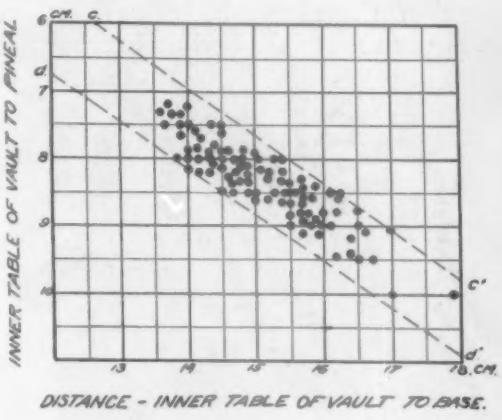

Chart 2.

Having thus established our normal curve it was considered that any pineal shadow lying to the left of the line *a-a'* was displaced anteriorly, and to the right of *b-b'* was displaced posteriorly, and any pineal shadow lying above the line *c-c'* was displaced upward and any below the line *d-d'* was displaced downward.

In order to estimate the value of pineal displacement, we studied the skull films of 268 cases of verified brain tumors of which 163 showed calcification of the pineal body.

Frontal Tumors. Posterior displacement of the pineal body was observed in 71 per cent of the frontal tumors with displacement occurring with about the same frequency in both gliomas and meningiomas.

Temporal Tumors. Posterior displacement of the pineal body was observed in 40 per cent of the temporal tumors and upward displacement was also observed in one case in which the lesion was low in the temporal region.

Parietal Tumors. Downward displacement was observed in 47 per cent of the

parietal tumors. Displacement is more apt to occur in meningiomas than in gliomas, the pineal body being displaced in 62 per cent of the parietal meningiomas and in 38 per cent of the parietal gliomas.

Occipital Tumors. Anterior displacement of the pineal body was observed in 44 per cent of the occipital tumors, displacement occurring with about the same frequency in meningiomas and gliomas.

Subtentorial Tumors. Upward displacement of the pineal body was observed in a third of the subtentorial tumors.

Acoustic neuromas and pituitary adenomas rarely displace the pineal body, displacement being observed in only 22 per cent and 10 per cent of these cases respectively.

Hydrocephalus per se was observed to produce a displacement of the pineal body in only 13 per cent of the cases. Camp has observed that cases of internal hydrocephalus often show a downward displacement of the pineal body. He calls attention to this as a possible source of error in diagnosing downward displacement as due to a parietal lesion when the disease is lower.

Craniopharyngeal pouch tumors rarely displace the pineal body although displacement was observed in one case with a rather large tumor.

There was upward displacement in one case in which there was an aneurysm of the basilar artery measuring approximately 4 cm. in diameter.

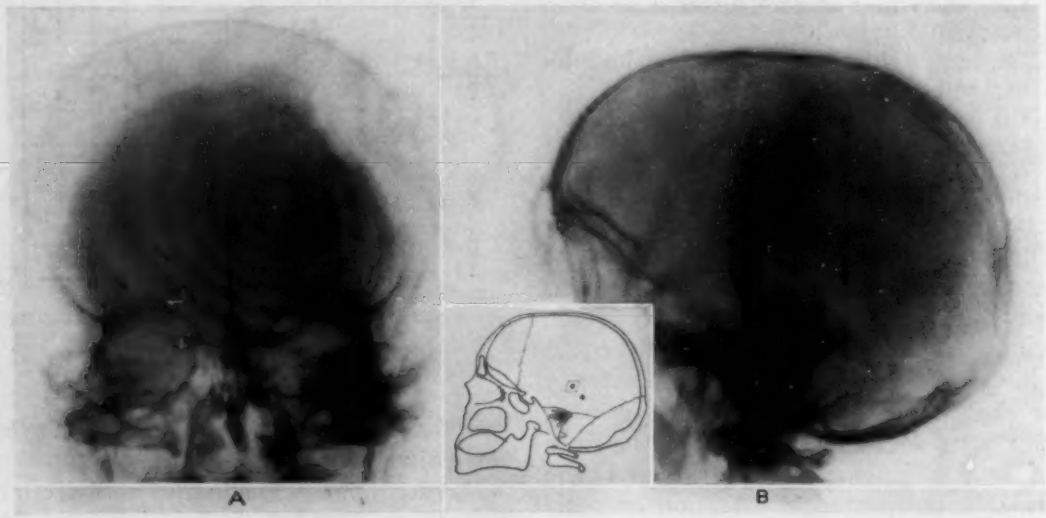

Fig. 4. A. Posteroanterior roentgenogram of a skull showing an enlarged meningeal channel in the left frontal region. B. Shows posterior and downward displacement of the pineal body. This with the enlarged meningeal channel permitted the roentgen diagnosis of a left frontal lobe tumor. This was confirmed at operation.

This work has been confirmed by Dyke at the Peter Bent Brigham Hospital where he comprehensively reviewed 494 cases of intracranial tumors of which number 253 had a roentgenologically demonstrable pineal body.

In regard to the value of displacement of the pineal or choroid plexus, Beals states that none of the patients in his series have had verified brain tumors, but it has been felt that the presence of these shadows in a normal position, in the few cases suspected of train tumor, has added valuable evidence against the presence of tumor.

Displacement of the pineal body in the lateral film of the skull is illustrated in Figure 4. A diagnosis of left frontal lobe tumor was made roentgenologically from the presence of a unilateral prominence of a meningeal channel in the right frontal

region and from marked posterior displacement of the pineal body. This diagnosis was confirmed at operation.

SOURCES OF ERROR

Displacement of the pineal body is a distinct diagnostic aid in the localization of intracranial lesions. It is not a method of precision, however, and observation of pineal displacement, particularly when correlated with thorough clinical studies suggesting intracranial pathology, certainly indicates the presence of disease and warrants further roentgenological study by encephalography or ventriculography. The sources of error in diagnosing displacement of the pineal body are:

1. Roentgenograms made with the head in an improper position.
2. Unusual-shaped skulls, particularly dolichocephaly.
3. Unilateral calcification in the choroid plexus.
4. Calcification in tumors in the pineal region.
5. Shadows due to psammoma bodies, sandkörper, brain sand, phleboliths, etc.

1. There are commercial devices for keeping the head straight for the anteroposterior or posteroanterior films but these are unnecessary. Naffziger has used a stethoscope upon which there is a pointer for obtaining direct anteroposterior views. Sosman has employed a pelvimeter fitted with ear pieces and a long pointer. The ear pieces are placed in the patient's ears and the head rotated until the pointer is directed straight upward at the target of the tube. The head is then held in this position by means of a bandage. The head leveler described by Pfahler is an ingenious and practical device. A mechanical device is not absolutely necessary, however, as the head can usually be adjusted by standing at the end of the table and placing a finger in each of the patients ears and rotating the head until the two fingers are equidistant from the table. Naffziger states that in anteroposterior or posteroanterior films of the skull, the pineal shadow is frequently obscured by the nasal accessory sinuses. When the direction of the rays is parallel to a line drawn between the external canthus of the eye and the external auditory meatus, the pineal shadow is seen to be projected well above the sinuses. In the observation of displacement of the pineal body vertically, anteriorly, or posteriorly, it is important that true lateral views are examined. The sagittal plane of the head must be parallel to the film.

2. Unusual-shaped skulls as a source of error have been discussed by Dyke. He found slight anterior displacement, using the method of Vastine and Kinney, in 75 cases, all in dolichocephalic skulls. In most of these, he states, the displacement was very slight and probably was of no significance, and this was noted at the time the measurements were made. "It is felt that a figure well below 14 per cent represents a truer number of pineals outside of the usual range in normal skulls" (Dyke). This possibility of slight anterior displacement in dolichocephalic skulls must be kept in mind.

3. Unilateral calcification of the choroid plexus, although rare, must be remembered as a possible source of error in reporting lateral displacement of the pineal body. This is illustrated by the case reported by Pancoast before the Philadelphia Roentgen Ray Society in 1930. A small dense circular shadow was seen which closely resembled the appearance of the pineal body both in size and structure. This shadow was observed in a position lateral to the midline and suggested lateral pineal displacement, but this error in diagnosis was prevented by encephalography and the shadow was shown to be due to unilateral calcification in the choroid plexus.

There is no unanimity of opinion in regard to the frequency of roentgenologically demonstrable calcification in the choroid plexus. Thus, Dyke, in his series of 2,724 skull examinations found demonstrable calcification in 5.1 per cent of the cases, while Beals in a study of 86 cases found the choroid plexus to be demonstrable in 28 per

cent of the cases. He describes the shadows produced by the choroid plexus as a somewhat oval shadow about 1 cm. in diameter, without very sharply defined borders. The density is not uniform, the shadow giving the impression of many superimposed small dots and small curved shadows. The two shadows are seen exactly opposite each other, one on each side of the midline and separated by about 4 or 5 cm. When the pineal is also visualized, the three shadows stand at the angles of an isosceles triangle, the pineal at the obtuse apex anteriorly, the two choroid shadows at the angles of the base posteriorly. Camp has called attention to the importance of differentiating between calcification in the pineal body and the choroid plexus, particularly when this latter calcification occurs unilaterally. This differentiation is usually possible due to bilateral calcification of the choroid plexus, and due to its position above and posterior to that region usually occupied by the pineal body. The calcification of the choroid plexus is usually larger, is often crescentic in arrangement and is more mottled, though this differentiation is not always sufficient and, although rare, the possibility of unilateral calcification of the choroid must be borne in mind as a possible source of error in reporting pineal displacement. When the choroids as well as the pineal are demonstrable, this mistake cannot easily be made.

4. Calcification in tumors in the pineal region is usually more extensive than that seen in the pineal body. Lesions which may produce calcification in this region are gliomas, meningiomas, tuberculomas and teratomas. These are discussed under tumors of the pineal body (vide infra).

5. O'Sullivan has described 3 cases of calculi occurring in the brain in which there might be some confusion as to whether it was a displaced pineal body. These brain calculi are thought to be calcification in old scars or old hemorrhages. They were single, dense, sharply outlined shadows the size of a cherry stone. His illustrations show shadows which might be confused with a laterally displaced pineal body but only one of the three cases was proved.

Calcification in aneurysms as reported by Sosman and Vogt occurs about the sella turcica and would not be confused with a pineal shadow. Calcification in parasitic cysts as reported in 2 cases by O'Sullivan as multiple, pea-sized, dense areas with irregular contours would not likely be confused with calcification in the pineal body. Calcified hematomas occurring within the brain have been described by Camp as irregular, dense, somewhat triangular shadows lying within the brain. These are larger and confusion with the pineal shadow is doubtful, since they are usually more laterally situated than the pineal body could possibly be.

TUMORS OF THE PINEAL BODY

Tumors of the pineal body are comparatively rare. Haldeman, in a comprehensive review of the literature, collected only 113 cases up to 1927. Elsberg, in a review of 767 cases of verified brain tumors from the New York Neurological Institute had only 2 pinealomas.

The classic contributions of Marburg, Krabbe, Tilney and Warren, Horrax and Bailey, and more recently Globus and Silbert, have shed much light on the pathogenesis of tumors arising in the pineal body, but there are many morphological features that are still obscure. The variability in structure is so great that a classification of these tumors into a single morphological group has been impossible. Krabbe has suggested the name pinealoma and this is probably as satisfactory as any offered thus far. The variability in morphology was shown in the review of the literature made by Haldeman in which the microscopic diagnoses were fibroma, psammoma, psammosarcoma, sarcoma, glioma, gliosarcoma, carcinoma, adenoma, adenocarcinoma, neuroglioma, neuroepithelioglioma, pinealoma, and pineoblastoma. Teratomas of the pineal body have been reported.

In regard to the *clinical aspects of tumors of the pineal body*, several authors have at-

tempted to summarize the symptoms that point to this condition. Discussing the diagnosis of pineal tumors in adults, Horrax states that, "In the presence of an intracranial pressure syndrome which simulates a cerebellar lesion, if there be added to the picture an involvement of one or both trochlear nerves together with recurring changes in the size of one or both pupils, and a tendency to spasticity in the lower extremities, a tumor of the pineal body should at least be suspected." Haldeman states that in preadolescent children a pineal tumor often produces the syndrome characterized by Pellizi as "macrogenitosomia praecox." Frankl-Hochwart says, "When one finds in a young individual, along with the general symptoms of tumor, as well as the local signs of a lesion of the corpora quadrigemina, abnormal body growth, unusual growth of hair, adiposity, somnolence, premature genital and sexual development, and finally intellectual maturity, one must think of pineal tumor." Probably the most significant of the eye signs are paralysis of upward movement, diplopia, abducens paralysis, ptosis, and absence of the light reflex (Haldeman).

Only a few of these tumors have been localized to the pineal body ante mortem. These observations have been reported by neurosurgeons or neuropathologists on cases in which the diagnosis was made only at the operating table or at the post-mortem examination. For this reason the literature contains few references to the roentgenologic findings. There is no reference to the occurrence of roentgenologically demonstrable calcium in the true pinealoma or pineoblastoma. Teratomas sometimes contain calcium (Sosman). The presence of calcification may be a diagnostic point by which teratomas may be differentiated from pinealomas (Horrax and Bailey), although in their only case of teratoma of the pineal body no calcification was seen. Altmann recently reported a dermoid arising from the pineal body in a boy eleven years of age, in which the diagnosis was made from the presence of a calcified tumor of the pineal body.

The presence of increased intracranial pressure with the production of an internal hydrocephalus can readily be understood by the roentgenologist when the position of the pineal body near the aqueduct of Sylvius is borne in mind. In the presence of the above symptoms the roentgenologist should search carefully in the region of the pineal for calcification. This will sometimes be seen in teratomas and dermoids.

Ventriculograms will show a blocking of the aqueduct of Sylvius with a resulting internal hydrocephalus. A defect may be observed in the posterior portion of the third ventricle due to the presence of the pineal tumor.

Encephalograms are of little positive value in the diagnosis of pineal tumors since air cannot enter beyond the fourth ventricle. Furthermore because of the increased intracranial pressure, the procedure is contraindicated.

Arteriography may be of value, as illustrated by the case of Egas Moniz, Pinto and Almeida Lima, in which a diagnosis of glioma in the pineal region was made by this measure and the findings confirmed by operation.

Gliomas, meningiomas, and tuberculomas are the lesions occurring in this region which must be differentiated from pineal tumors.

Gliomas usually are on one side or the other, rarely arising from the pineal region, although Horrax and Bailey have reported spongioblastomas arising from the pineal body. Calcification in gliomas frequently occurs (12.9 per cent—Mason; 11 per cent —Sosman; 5 per cent—Camp; 13.5 per cent—Van Dessel), and therefore when occurring as a midline tumor in the pineal region may be confused with calcified tumors of the pineal region. The presence of a calcified pineal body which seems to be of normal size will make one suspect a tumor in this region of *other* origin, particularly if the pineal body is seen to be displaced.

Meningiomas arising from the pineal region have been observed. Elsberg, in a review of 767 verified tumors of the brain, found 13.2 per cent to be meningeal fibroblastomas of which only a fourth could be regarded as parasagittal, and examination of his illustrations shows that relatively few of these are in a position where they would be confused with tumors of the pineal body. These parasagittal meningiomas usually arise from the meninges of one side or the other, rarely being midline tumors. Sosman believes that it is impossible to differentiate between a glioma and meningioma from the character of the calcification to be seen in the roentgenograms, unless, of course, the calcification in a meningioma is adjacent to the skull and characteristic spicule formation and perforating vessels are seen. Masson could observe no distinguishing difference between calcification in gliomas and meningiomas. "From the character of the calcification it is seldom possible to differentiate with certainty between the visible evidence of lime salt deposit in a gliomatous growth and the results of a similar process in an area of degenerated brain as a result of vascular changes, or in an old calcified brain abscess" (Masson). I know of no definite characteristics which would serve to differentiate the calcification in the above conditions from that in calcified tumors of the pineal body. Kingreen described a few cases in which calcification was observed in tuberculomas, but no distinguishing difference in the calcification was described by which that condition could be differentiated from a calcified pineal tumor.

SUMMARY

Displacement of the pineal body has been discussed and illustrated.

Evaluation of pineal displacement as a diagnostic aid and the possible sources of error have been considered.

The literature relative to pineal tumors has been reviewed.

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THE ROENTGEN FINDINGS IN SUPPURATION OF THE PETROUS APEX (PETROSITIS)*

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UNTIL recently the diagnosis of suppuration of the petrous apex was not usually made except after post-mortem examination, and even today in spite of the graphic roentgen demonstration of this change in the petrous bone there are still clinicians who do not recognize its clinical significance.

Petrositis, or suppuration in the apical portion of the petrous pyramid, is a clinical entity. It is a complication of an acute otitic infection, and usually follows an acute coalescent mastoiditis. Petrosal suppuration may occur in a diploic bone or in a pneumatic bone. The suppuration in the former type of bone is an osteomyelitis, while a suppuration in the latter type produces changes which are analogous to a suppurative lesion in a well-pneumatized mastoid process. This paper will be limited to the study of petrositis as it occurs in a pneumatic bone.

Pneumatization of the temporal bone is the normal process in development. There is considerable variation in the character and extent of pneumatization. When pneumatization is extensive, cells are found occupying portions of the squamosa and occipital bones, around the mouth of eustachian tube, floor of middle ear, tegmen tympani, petrous pyramid and petrous apex. Siebenmann, Girard, and many others, have described tracts of cells leading into the petrous apex from the middle ear. Pneumatization in the petrous tip varies considerably. One or two large pneumatic cells may be present (Collet, von Troelisch, Merkel).

Mangabeira-Albernaz, Profant, Burger, Frenckner, Jungert, and others, believe that an infection in these cells (petrous apex) is the cause for the so-called Gradenigo syndrome. Bigler demonstrated roentgenologically an abscess of the petrous apex, which he believed was the cause of Gradenigo's syndrome. Eagleton describes caries of the petrous apex with sixth nerve involvement.

In a series of 15 cases of petrous suppuration, which were under the observation of Kopetzky and Almour, but 2 cases showed a sixth nerve paralysis. This would tend to indicate that an abducens palsy is not a constant concomitant of petrous suppuration. Further, Kopetzky and Almour quote and agree with Vogel and others, who do not consider the so-called Gradenigo syndrome as a clinical entity or characteristic of a specific lesion. Jungert confuses the two conditions for he speaks of the Gradenigo syndrome with and without petrous suppuration. He claims that the cases which recover do not have petrous suppuration; that these cases showing clinical and roentgenological evidences of petrous suppuration must be operated upon and that the simple or radical operation is inadequate and that measures must be instituted to drain the petrous apex even if the labyrinth is to be sacrificed. He also cites 4 cases of otitic meningitis wherein at autopsy the cause in all 4 cases was found to be an empyema of the petrous apex; yet in none of these cases was a sixth nerve paralysis present. It seems clear that the diagnosis in vivo was not made because of the preconceived belief that a sixth nerve paralysis (Gradenigo's syndrome) is the essential for the recognition of the clinical and pathological entity of suppuration in the petrous apex.

It is of the utmost importance to understand that a petrositis may exist without sixth nerve palsy. Sears states: "Pathology

* From the Department of Roentgenology, Beth Israel Hospital, New York City (Dr. I. S. Hirsch, Director). Read at the Thirty-third Annual Meeting, American Roentgen Ray Society, Detroit, Mich., Sept. 27–30, 1932.

of the petrous bone in otogenic paralysis of the abducens, as observed by careful autopsy is slight in quantity, covering all autopsy records available. However, the material at hand is not too convincing; to offset the abscess cavities at the petrous tip there are others to match them in which no paralysis existed." Only by realizing this fact will measures be instituted promptly to drain the focus in the petrous apex and prevent a meningitis in such cases wherein the clinical signs and roentgenological evidences of the disease are present. These cases fall into two groups: petrous suppuration with and without adequate drainage.

Petrous Suppuration with Inadequate Drainage. The usual history is that of a simple mastoidectomy upon an extensively pneumatized temporal bone with an apparently normal convalescence. After a few days the temperature reaches normal, the aural discharge gradually diminishes and disappears, and the wound is practically healed. This is followed by an interval of well being which varies from a few days to several weeks. There is usually a sudden onset of pain in or about the eye, particularly retro-orbital, which is the first typical symptom, and occurs on the same side as the suppurative lesion. This is due to irritation about the Gasserian ganglion, more particularly the ophthalmic branch of the fifth nerve. Eagleton attributes the retro-orbital pain to an inflammatory reaction of the dura overlying the diseased petrous tip. As a rule, there is a sudden profuse otorrhea accompanying the eye pain. Associated with these symptoms is a low grade temperature. A roentgenographic examination at this time shows evidences of petrosal tip suppuration. Operative interference is indicated in the presence of the above symptomatic group with positive roentgen findings. Eagleton says that retro-orbital pain in the presence of a sepsis means caries of the petrous apex. Delay results in endocranial extension to the meninges with a fatal termination. It is of importance to note that the presence of a sixth nerve paralysis is not a necessary factor in diagnosis.

Fig. 1. Position of patient. Inferosuperior projection of base of skull.

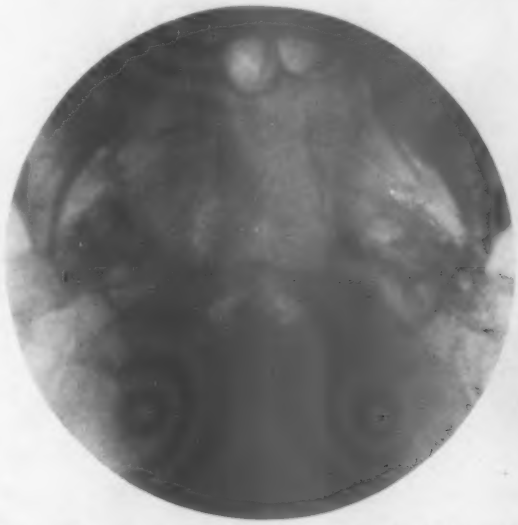

Fig. 2. Intense atrophy and loss of trabeculations in the left petrous apex. Suppuration in the petrous apex with inadequate drainage.

Petrous Suppuration with Adequate Drainage. The history is usually the same as the aforementioned type: a normal convalescence after a mastoidectomy. There is, however, no typical eye pain and there is no development of sepsis. The important clinical factor is the return or continuance of a profuse otorrhea, which is persistent

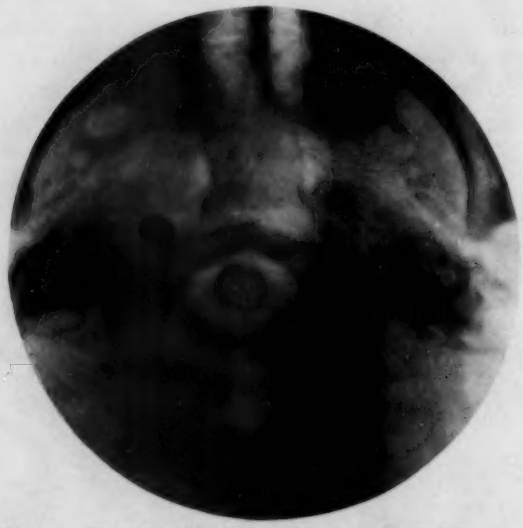

Fig. 3. Considerable destruction of the left petrous apex. Extradural extravasation of lipiodol. Suppuration in the petrous apex with inadequate drainage.

following mastoidectomy on an extensively pneumatized bone. The roentgenographic examination shows changes characteristic of petrous suppuration.

This condition, if the petrous apex is drained, resolves and heals completely; if not operated upon a protracted otorrhea results, due to continuous drainage through broken down cells or through a fistulous tract into the middle ear.

Friesner and Druss state that in these cases recovery is an evidence of a mild infection and adequate drainage. Kopetzky and Almour, however, maintain that the virulence of the infection is of no consequence and that adequate drainage is the all-important factor. Frenckner quotes Voss, who claims that pus foci in the pyramids have a tendency to heal if the tympanum and antrum are well drained. Uffenorde states that one must think of a pyramidal tip suppuration where the middle ear continues discharging after surgery for the relief of an acute mastoid suppuration.

TECHNIQUE

For the demonstration of suppuration in the petrous apex, the most information is obtained from a film of the base of the skull, because both pyramids are depicted at the same time, and are contrasted by the surrounding bony structures and show their structural character and detail more clearly.

The routine examination of the mastoid processes includes one view of the base of the skull. Should a complicating petrous suppuration develop, the original film of the petrosae is available for comparison with subsequent films permitting the detection of the earliest changes.

Figure 1 shows the position of the patient. The patient is supine, the head is lower than the rest of the body and rests on the vertex, so that a line drawn through the external auditory canal and superior orbital margin is parallel to the cassette, which is horizontal. The sagittal plane of the head is perpendicular to the table. The tube is tilted upward 15 degrees. The central ray is directed one inch in front of the external auditory canal, in the midline. The same position can be accomplished by hyperextending the body, using books or a block as a support in the mid and lower dorsal regions. A small pillow is used to cover the block, the elevation being about 8 inches.

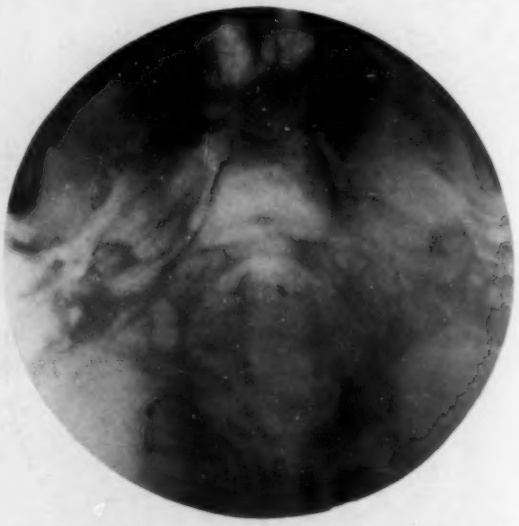

Fig. 4. Intense atrophy of the right petrous apex. No operative interference subsequent to mastoidectomy. Patient is symptom-free except for otorrhea. Suppuration in the petrous apex with adequate drainage.

INTERPRETATION

The value of the roentgen diagnosis lies entirely in the fact that suppuration of the petrous apex can be recognized before the development of meningeal infection, and in sufficient time for surgical drainage to be instituted.

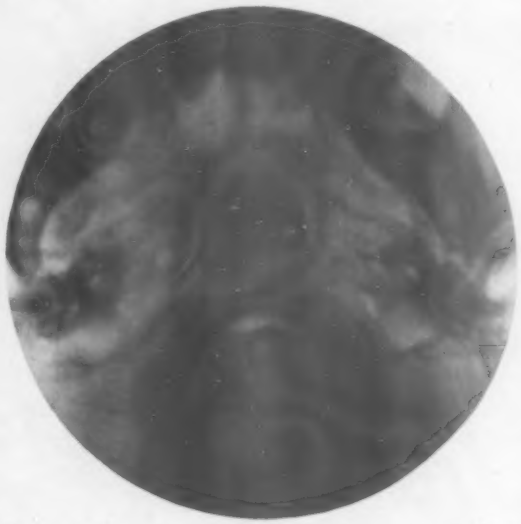

Fig. 5. Bilateral mastoidectomy six years ago. Right side healed. Persistent discharge from left side. Left petrous apex shows a diminution in aeration and thickened trabeculae.

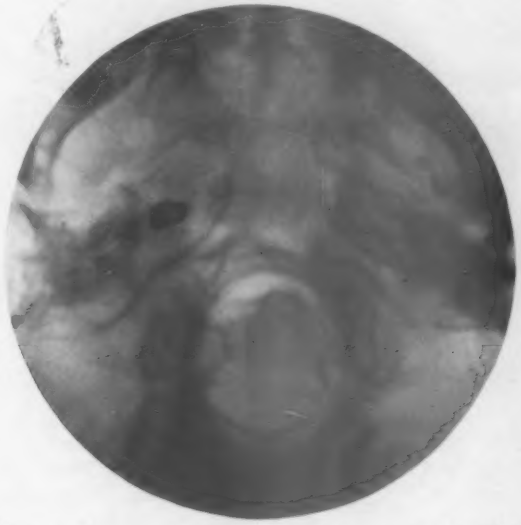

Fig. 6. Same as Figure 5. Revision operation with injection of lipiodol into mastoid antrum. The lipiodol extended into the petrous apex through tract of cells above labyrinth.

As previously stated, a film of the base of the skull is routinely made in all mastoid examinations. This has been of inestimable value in these cases which subsequently developed a petrositis.

Arnoldson, in a discussion of Hellmer's paper, cites 7 cases of otogenic meningitis which, at autopsy, showed the source to be a suppuration of cells in the petrous apex. He stresses the value of determining roentgenologically the presence of pneumatization in the petrous apex in all cases of otitic suppuration prior to mastoidectomy. Only in this way, he believes, can one be on the lookout for a possible complication in the petrous apex.

In all cases of suppurative mastoiditis, the petrous pyramid shows a generalized diminution in aeration. This change in aeration is due to a congestion of the membrane lining the air spaces. The finding is similar to a dimintuion in aeration of a pneumatic mastoid such as is found in an otitis media.* This change is not due to a petrostitis. None of our cases showed any changes of a suppurative petrositis until some time after a mastoidectomy had been performed. This, however, does not preclude the possibility of its presence before a mastoidectomy. Further study of this original film shows the character and extent of the pneumatization in the pyramid. It is readily compared with the opposite petrous pyramid. In the event of a bilateral otitic infection, both pyramids would show similar changes, and the subsequent development of petrostitis on one side or the other would be readily detected.

A roentgenographic examination at the time when a petrositis has developed shows decalcification of the bony trabeculae which subsequently disappear. This is followed by decalcification or atrophy of the entire apical portion, the contour remaining intact. The atrophy may be so intense that the petrous apex is either faintly or not at

* Geyman and Clark divide petrositis into three groups: occurring with acute otitis media, with acute mastoiditis, and as a postoperative sequel.

all visualized. Perforation and finally destruction of a considerable portion of the apex may ensue. This atrophy or decreased density is found only internal and anterior

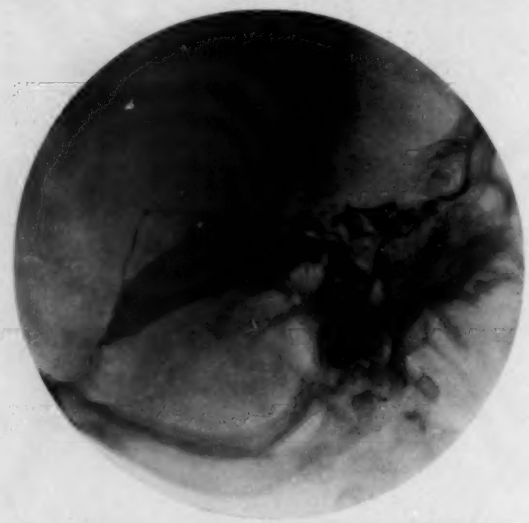

Fig. 7. Petrous suppuration with inadequate drainage; patient died of meningitis. Lipiodol injected into petrous apex, post mortem. The lipiodol extends posteriorly above the tentorium and into the anterior and middle cranial fossae.

to the labyrinth. The basal portion of the pyramid retains its density. By contrast, the basal portion of the pyramid shows a relative increase in density, which is only apparent and not real. Operative interference is imperative in the presence of clinical symptoms and the above findings.

Cases of petrous suppuration with adequate drainage also show positive roentgen findings, although clinical symptoms may be absent. These cases should be operated upon to eradicate the focus of infection in the petrous apex. If not operated upon it will be the cause for a protracted otorrhea.

The petrous bone in a case with a protracted otorrhea shows a generalized diminution in aeration. There is no atrophy. The apical contour is intact. The trabeculae are not distinctly visualized, and may be destroyed; or the trabeculae may be thickened. The basal portion of the pyramid shows a productive osteitis.

In 6 cases lipiodol was injected into the petrous apex. In 5 cases the injection was made either through the fistulous tract or the operative opening into the tip. In the sixth case the lipiodol was injected into the middle ear (Gottlieb).

One case, which died from a purulent leptomeningitis, showed the spread of the lipiodol into the anterior cranial fossa, across the middle fossa, and over the tentorium. This outlined the pathway of infection, which was through the petrous apex.

Another case with no meningeal symptoms showed the lipiodol in the petrous apex and in the cranial cavity above the tentorium. This patient presented a typical clinical picture for several weeks but it apparently was not recognized. Roentgenographic examination showed changes of petrous suppuration, and immediate operation was advised. Timely operation probably prevented the development of a meningitis. The patient is alive today, and on the road to recovery, but is still in the hospital.

In one case which showed marked apical destruction the lipiodol escaped from the petrous apex subdurally into the region of the inferior petrosal sinus. Seven months

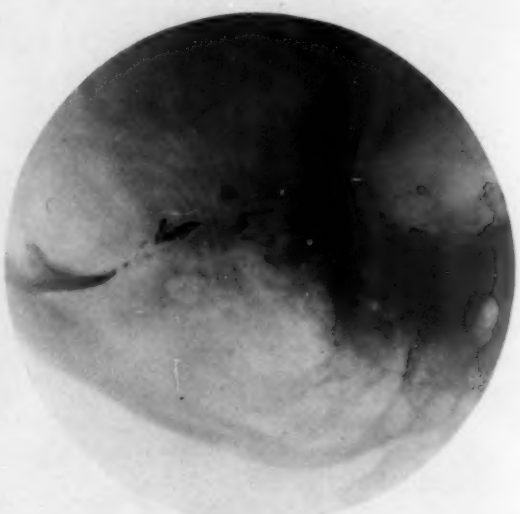

Fig. 8. Petrous suppuration with inadequate drainage, right side. No meningeal symptoms. The petrous apex was drained and lipiodol injected. The distribution of the lipiodol is the same as in Figure 7. Timely operation prevented the development of a meningitis.

later the lipiodol was fragmented but in the same location. In the other 3 cases the droplets of lipiodol were confined to the petrous apex.

One case in which the entire tip was not visualized due to the intense atrophy showed the lipiodol confined entirely within the apex. There was no extravasation subdurally. This failure to visualize the borders of the petrous apex is not an indication that a perforation through the apex has occurred. Roentgen examination two weeks later showed the lipiodol in the petrous apex, but the size of the lipiodol shadow was smaller. A part of the lipiodol must have drained through the middle ear.

The injection of lipiodol into the petrous apex, as practiced by Kopetzky and Almour at the time of operation or shortly thereafter, is not attended by any untoward sequelae.

In one case, with a persistent discharge from the wound, lipiodol injected into the middle ear at a revision operation depicted the tract of infection above the labyrinth and into the petrous apex.

Roentgen examination of several of the operatively cured cases of petrous suppuration, six months to one year postoperative, show a return to normal density of the apical portion, with an increase in density in the perilabyrinthine area or basal portion due to a productive bone change. The typical bony cell walls do not reform.

SUMMARY

1. Suppuration in the apical portion of the petrous pyramid is a complication of an acute otitic infection, and can be recognized clinically and roentgenologically. Sixth nerve paralysis, in cases of petrous suppuration, is by no means an important or essential finding; it may be a coincidental finding with a lesion in the pyramid, and again the petrous pyramid may be extensively involved without any signs of involvement of the sixth nerve.

2. The clinical recognition depends upon the following:

a. Profuse otorrhea, occurring after a period of cessation, following a simple mastoidectomy.

b. Pain along the distribution of the ophthalmic branch of the fifth nerve, retro-orbital.

c. Low grade sepsis.

3. The roentgen findings are diminished aeration, deficient trabeculations, intense atrophy, perforation and finally destruction of the apical contour. These changes occur only in pneumatized petrous pyramids.

4. Operative interference is indicated when clinical symptoms and roentgenological findings are present.

5. Cases showing roentgenological findings and no clinical symptoms have adequate drainage, and, if not operated upon, will probably terminate in a protracted otorrhea.

6. The roentgenologic findings in lesions of the petrous pyramid in other than pneumatized bones are not discussed in this paper since they constitute a different lesion.

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Vol. XXX, No. 2

THE ROENTGEN DIAGNOSIS OF SPINAL DEFORMITIES

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IT IS the purpose of this discussion to present the various diseases which, when they affect the spine, may result in deformity of vertebral bodies; to classify these diseases; to describe the roentgen appearance of the vertebrae under these various conditions with special regard to differential diagnosis; and finally to present a bibliography limited to the more or less recent or easily accessible literature to serve as a reference guide to those interested in any particular phase.

CLASSIFICATION

Congenital Anomalies:[31,40,42,51,101,113,137,147]
1. Absence of half or all of the vertebral body: Klippel-Feil syndrome.
2. Vertebral fusion: complete, unilateral, cross fusion.
3. Supernumerary vertebra.
4. Supernumerary ribs.
5. Hemihypertrophy.

Developmental Disorders:[23,32,51,52,61,68,82,106,135,141]
1. Retropulsion of the nucleus pulposus.
2. Kyphosis dorsalis juvenilis; osteochondritis; epiphysitis: subchondral necrosis.[19,24,86,122,149]
3. Osteogenesis imperfecta.
*4. Local malacias; presenile osteoporosis.[110]
5. Chondrodystrophy.[130,139]
6. Dwarfism.[119]

Trauma:
1. Fracture with or without dislocation.
2. Kümmell's disease; Kümmell-Verneuil's disease.[73,74,75,76,77]

Infections:
1. Osteomyelitis
   (a) *Staphylococcus aureus*[2,13,27,54,80,88,105,114,135,145] (Fig. 1A, B, C).
   (b) Pneumococcus.[92]
   (c) Cerebrospinal meningitis.[11]
   (d) Typhoid.[3,5,9,50,89,98]
   (e) Typhus.[58]
   (f) Malta fever.[25,116,126]
   (g) Brucella abortus.[62,78]
   (h) Grippe.[17]
   (i) Smallpox.[28]
   (j) Leprosy.[66]
   (k) *B. proteus* (personal experience).
2. Tuberculosis.[33,34,42,127,136]
3. Syphilis.[1,28,29,57,142,148] (Fig. 2).
4. Charcot's spine.[83,103,141]
5. Fungous infections.[14,26,96,104,111,129]
6. Echinococcus disease.[12,55,79,146]

Metabolic Disorders:
1. Hunger osteopathy.[64]
2. Osteomalacia.[23,51,64,71]
3. Osteitis fibrosa cystica.[7,39,124,138]
4. Osteitis fibrosa (Paget's).[42]
5. Pituitary disease.[97]
6. Amyloid disease.[4,37,85,122] (Fig. 3).
7. Gaucher's disease;[16,59,107,108,143] Schüller'-Christian's syndrome; Niemann-Pick's disease[109] (Fig. 4).
8. Gout.[84]

Blood Dyscrasias:[41,43,67,90,118]
1. Leucemia (Fig. 5).
*2. Chloroma.

Primary Tumors:[41,43,65]
1. Giant cell tumor.[30,81,120]
2. Sarcoma; chondromyxosarcoma.[67,69,112,117,133,144]
3. Ewing's tumor.
4. Myeloma.[8,10,36,44,102,124]
5. Angioma.[6,20,47,49]
6. Chordoma.[60]
*7. Radium osteitis (Martland).[87]

Metastatic Tumors:[41,56,64,66,93,128]
1. Carcinomas of lung, thyroid, gastrointestinal tract, nasopharynx, breast, prostate, liver.[15,22,38,53,61,86,94,131,132]
2. Hypernephroma.[35,46,100]
3. Neurofibroma.[18,91]
4. Rhabdomyoma.[21]
5. Sarcomas, as, for example, of liver (personal experience).

Unclassified:
*1. Hodgkin's disease and lymphosarcoma.[45,70,72,95,115]

Pressure Atrophy:
1. Aneurysm.[121]
2. Extravertebral tumor (personal experience).

* These conditions are arbitrarily so classified. Revision may be needed with the acquisition of further knowledge

Congenital Anomalies. This group of spinal deformities is a difficult one to analyze except in the light of embryological studies. The vertebrae in their development are formed by the union of the ad-

Fig. 1A. Osteomyelitis. Onset of back pain one month after evacuation of furuncle. *Staphylococcus aureus* sepsis. (Operation.) February 16, 1932.

joining halves of protovertebrae and several abnormalities may result at this stage. In this group belong the vertebral fusions, complete, unilateral and cross, due to failure of the halves of the protovertebrae to separate. There may be wedging of one or more vertebrae. Normally a canal remains at the site of the previous interprotovertebral space which serves as a locus minoris resistentiae. That a congenital wedging can occur without the presence of any disease, such as tuberculosis, appears from the case described by Schulthess, in which there was a lumbar kyphosis in a new-born child with a spina bifida, the deformity having arisen as the result of a fusion of L_3 and L_4 into a wedge-shaped body. Similar studies have been made by Delahaye. Deformity of a supernumerary vertebra is due to the fact that there is no support from an accompanying rib. This causes a lateral backward subluxation and wedging of the offending vertebra. Supernumerary ribs also result in a lateral subluxation and lateral wedging of a vertebra. Often the wedging is not apparent in the lateral film alone. The Klippel-Feil syndrome is associated with the absence of one or more cervical vertebrae, sometimes with wedging of one of the remaining vertebrae and marked deformity. These cases have been reported in great detail in the German literature.

Developmental Disorders. The anatomical studies of Schmorl and their interpretation roentgenographically by Calvé and Galland have established the importance of the nucleus pulposus in a rational understanding of those deformities appearing during development. Occasionally it has been noted that there is a posterior displacement of the nucleus; the fulcrum upon which the vertebrae hinge is therefore more posterior than usual and as a result the anterior intervertebral spaces are narrowed and there is wedging of the corresponding vertebrae. This type of kyphosis is diagnosed by the number of vertebrae involved, the rather uniform degree of wedging and by the occasional appearance of calcification in the nucleus. Undoubtedly, most of the so-called "postural" changes previously ascribed to rickets result from this cause. At no time is there collapse of the bodies or tendency to fusion in rickets. Herniation of the nucleus into spongiosa does not result in deformity, although the latter may appear with an associated osteoporosis.

Kyphosis dorsalis juvenilis, originally described by Scheuermann, is characterized by the fact that it most frequently appears in the 10th and 11th dorsal vertebrae; there is a more or less wedge-shaped vertebra at the culminating point of the

kyphosis. The epiphyses are often larger anteriorly than posteriorly. Frequently they are slightly retracted, differently shaped and situated so as to be in apposition with the vertebral bodies. The whole process thus gives the impression that the juxta-epiphyseal tissue is compressed or atrophied. There is no further alteration when the epiphyses become united with the vertebral bodies. In several cases the affected vertebrae become foreshortened and triangular in shape and there may be spur-like prominences. The diseases described by Calvé and by Buchman are probably the same in nature, although in the so-called Buchman's disease wedging is not a common feature. Rather there is marked irregularity of the articular surfaces of the vertebrae with deformity of the epiphyses. Some cases such as that of Martin and Roesler show similar marked wedging and are listed under the general title of subchondral necrosis.

Deformity of the vertebral bodies as a characteristic of osteogenesis imperfecta is not a common finding roentgenographically. It has been noted pathologically and then apparently consists of bizarre deformities, easy of diagnosis when the deformities of the remainder of the skeletal system are noted.

The local malacias also described as presenile osteoporosis, the deformities of achondrodystrophies and dwarfism, are chiefly due to the fact that the resistance of the bony tissue of a vertebra is less than that of the nucleus pulposus and the intervertebral discs are thus pushed up deep into the vertebrae and the latter appear as the vertebrae of fish (Fischwirbel), that is, they are lenticular or biconcave in shape. For this reason the collapse of the bodies is uniform and there is no narrowing of the intervertebral discs, if anything, a slight widening; there are no hypertrophic changes.

Trauma. Fractures of the vertebral bodies are usually compression fractures except in the cervical region where they may be of the longitudinal fissure or crushing type. They may, of course, appear with or without dislocation. The compression is usually most marked anteriorly unless there have been, in addition, fractures of the vertebral appendages. The intervertebral space remains intact. After a varying length of time, hypertrophic spurs form at the margins of the injured body and often also at the anterior articular surface of the adjoining vertebra. In fact, the presence of localized hypertrophic spondylitis, with wedging of a body, and without narrowing of the intervertebral discs, usually indicates the presence of an old compression fracture of this body. In 1891 Kümmell described a condition often due only to a slight trauma which may in-

Fig. 1b. March 18, 1932.

Fig. 1c. April 15, 1932.

volve the vertebral column indirectly, and in which there are no immediate signs except for a transient period of pain in the back, but, after months of complete well-being, a rarefaction of the vertebrae occurs, probably due to an interference with its circulation leading to a nutrition atrophy. Autopsy early in this condition has shown small hematomata within the vertebral body. It is obvious, therefore, that as in the case of hemangiomata of the spine (loc. cit.) there may never be collapse of the body but that, on the other hand, collapse may occur at any time subsequent to the injury. It follows, too, that in a genuine case of Kümmell's disease there was never any fracture and that roentgenograms following the injury will show no abnormality. Further, it is only in the presence of such roentgenographic evidence that subsequent post-traumatic vertebral deformity can be ascribed to Kümmell's disease. The Kümmell-Verneuil syndrome is the presence of collapse subsequent to injury with a general malacia of the spine in addition.

Infections. It is our finding that there is a more or less characteristic appearance of the vertebrae, roentgenographically, when they are affected by the staphylococcus, pneumococcus, meningococcus, *B. typhosus* or *paratyphosus*, "grippe," *B. melitensis*, or *B. proteus*. This typically is a localized, ragged, hypertrophic spondylitis, with uniform narrowing of the adjacent intervertebral space and a slight wedging of the body progressing into real destruction and collapse (particularly when the cervical region is affected), with or without abscess. There is always a thickening of the perivertebral fibrous tissue. The features appear in this approximate chronological order. When the infection is due to a pyogenic organism, there is often destruction of a vertebral appendage. This is, of course, a generalization; the changes do not appear until late in the disease, often not for several months after the appearance of symptoms referable to the spine. It is within the experience of many that a vertebral body grossly invaded, as found at post mortem, had shown no definite changes in the roentgenogram. It is important, however, to know that the changes described above do occur in these infections, and that not all narrowing of the intervertebral disc is due to tuberculosis. It is of equal importance in the differential diagnosis from perinephric abscess. Curiously enough, syphilis characteristically gives a different picture, namely, a uniform narrowing of the vertebral body without any change in the intervertebral space and no bone reaction. The only other infection which gives the latter picture, within our experience and as far as can be gleaned from the literature, is an infection with *Brucella abortus*. In the latter, however, the picture is variable. In Jensen's case, for example, there was uniform nar-

rowing of these vertebrae each definitely resembling that of syphilis, while in the case of Lassen, there was no collapse, but a narrowing of the intervertebral joint and hypertrophic spondylitis. Undoubtedly this disease as it affects the spine deserves further study. Smallpox is mentioned chiefly for its potentialities. A definite collapse due to this cause has not been described.

As regards *tuberculosis*, the roentgenographic appearance is best studied in conjunction with the types of pathological invasion. Following the articles of Doub, and the observations of Sgalitzer, tuberculous involvement of the spine may be said to occur in the following ways:

1. Central involvement of the body with a minimum of symptoms until necrosis causes collapse of the body. There is then involvement of the intervertebral disc and adjacent vertebrae.
2. Epiphyseal type of involvement. There is an early narrowing and disappearance of the disc with coaptation of the vertebrae. Early collapse and kyphosis are not seen. Abscess may be the earliest sign.
3. Anterior or peripheral variety. The involved area is below the anterior longitudinal ligament in the anterior portion of the body. It may, however, secondarily invade the body and become central.
4. The vertebral appendages may be invaded.

It is obvious then that differentiation of the first variety from kyphosis dorsalis juvenilis may be very difficult; that the epiphyseal variety may simulate a pyogenic osteomyelitis; that the anterior variety may only be suspected from the demonstration of an abscess. One point, however, may be of assistance; tuberculosis in the absence of secondary infection usually shows very little new bone formation although even this perhaps occurs more often than is thought. The course of the disease is of the utmost differential importance.

Fig. 2. Syphilis (clinical). Case of cerebrospinal syphilis.

The Charcot spine is characterized by the same appearance as that noted in other joints, the extensive fragmentation of the anterior surface of the bodies. In our experience, this condition will not be confused with any other condition, except perhaps the fungous infections. The latter, however, practically always have an external fistula and roentgenograms are made usually out of curiosity rather than for diagnosis. Echinococcus disease may result in collapse of a vertebra, often with sclerosis about it. Sometimes there is complete destruction. There is no bone reaction nor atrophy. The intervertebral discs are intact. Before collapse, there are round unilateral and unilocular excavations involving one or adjacent vertebrae.

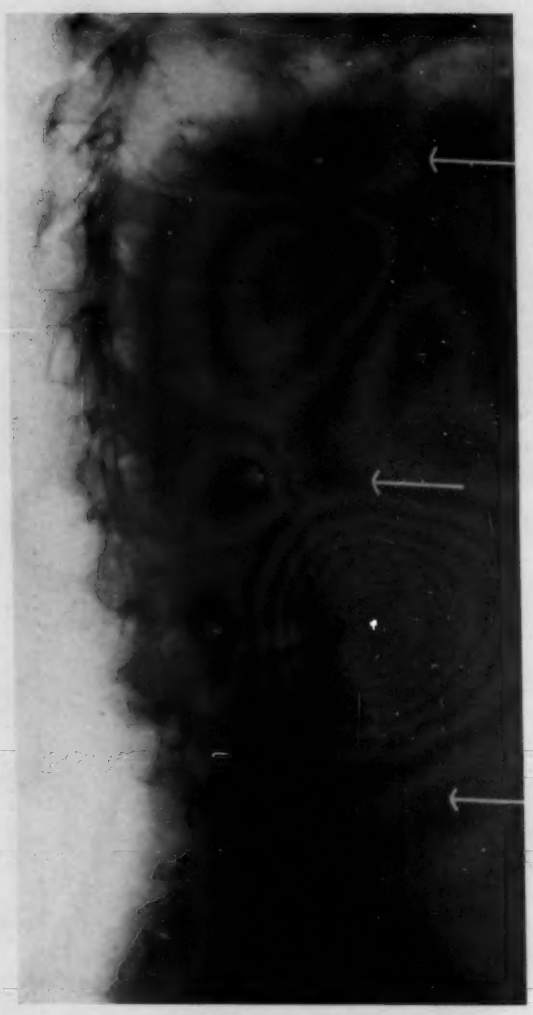

Fig. 3. Amyloidosis (autopsy). Amyloidosis of the liver, bone marrow, adrenals, kidneys and pancreas with collapse of first dorsal and first lumbar vertebrae—etiology not found.

Metabolic Disorders. There are several diseases which may be included in this group which are characterized by practically the same features, namely, a change in the bony structure of the vertebra so that it loses its normal resistance and becomes uniformly compressed by the intact intervertebral disc. The vertebral body assumes the shape of the "Fischwirbel." When the disease is general, all of the spine may be affected, as in osteomalacia. The discs here appear to swell and become spherical. In the hunger osteopathy extensivelydescribed by the Germans, a single vertebra may show this change. Amyloid disease, with invasion of the spine may result in a "Fischwirbel," as in the case of Mandl. There may, however, be uniform collapse without material change in shape except for some wedging. The latter when it occurs is the usual finding in the primary generalized xanthomatoses (Gaucher's disease, Schüller-Christian's syndrome and possibly Niemann-Pick's disease), where the body of the vertebra is completely necrotic and only a thin atrophic cortex and a few spongy trabeculae remain. There may be complete destruction and scar tissue replacement. Kyphosis of this type is often seen with acromegaly in association with pituitary adenoma. Characteristically, then, this group of metabolic diseases is characterized by a narrowing of the vertebral body with either wedging or the assumption of the lenticular shape, and with either no change in the intervertebral space

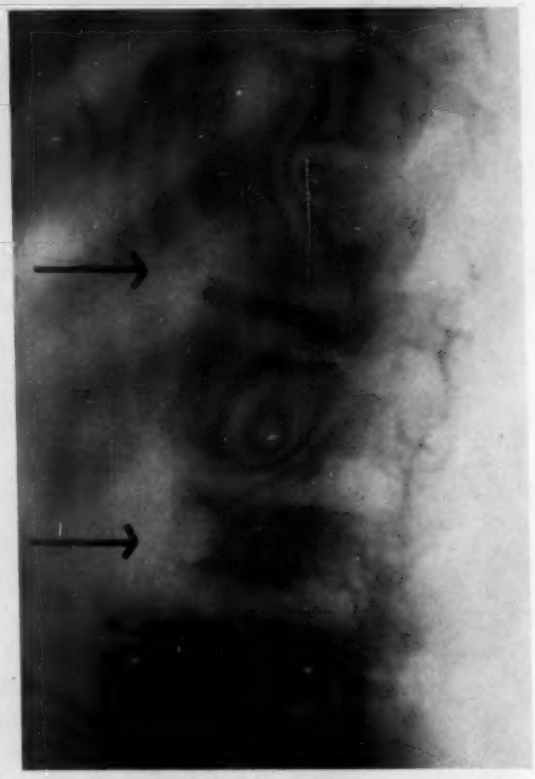

Fig. 4. Gaucher's disease (clinical).

or a relative widening with a spherical appearance. This same appearance is seen in Paget's disease when the rarefying osteitis predominates over the productive process, and particularly when the body is affected to a greater extent than the arches, an anterior bowing results. From the roentgenogram alone, the differentiation of osteitis fibrosa cystica (von Recklinghausen) and osteomalacia often cannot be made. The progressive narrowing of the vertebrae, with the assumption of the "Fischwirbel" shape are characteristic of both. In osteomalacia, the disease is more generalized earlier; in von Recklinghausen's only two or three vertebrae may be involved as far as the roentgenogram is concerned. Examination of the other bones and evidence as to the presence or absence of a parathyroid tumor are of importance.

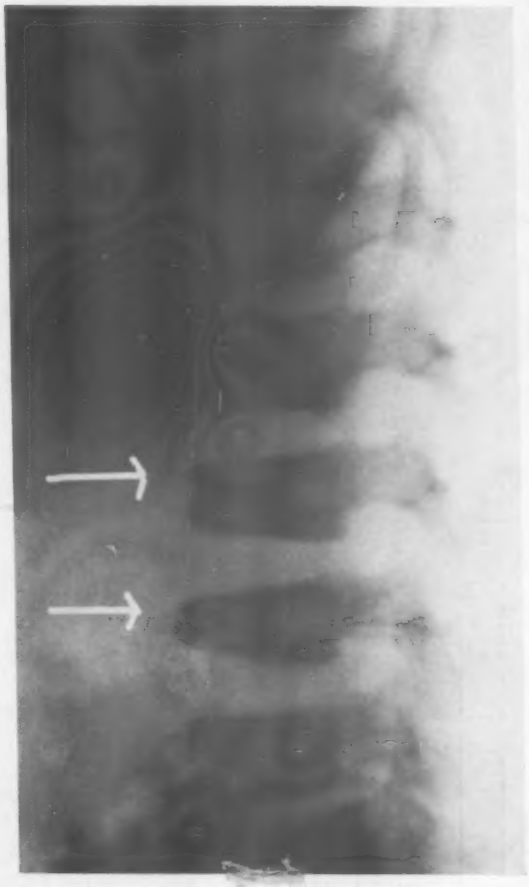

Fig. 5. Myelogenous leucemia (biopsy). Boy aged five with large liver and spleen. Blood count: hemoglobin, 60 per cent; white blood cells, 4,900; polymorphonuclear leucocytes, 1 per cent; myelocytes, 4 per cent; myeloblasts, 80 per cent.

Fig. 6. Hodgkin's disease (biopsy).

Blood Dyscrasias. In 1914, Rolleston and Frankau reported a case of acute leucemia simulating caries of the spine. The cancellous tissue of the bodies of the vertebrae was so soft that it could be cut quite easily, and the compact bone was thinned out. There was no collapse of the body. Microscopic examination showed a leucoblastic reaction (lymphocytic-like) but the cells were regarded by the pathologist as myeloblasts or their precursors. The case of Melchior was that of a lymphatic leucemia. Pains in the bones in chronic myelogenous leucemia is a well-known finding, and in Figure 5 is seen a vertebral wedging in a case of chronic

Table I

SUMMARY OF DISEASE CHARACTERISTICS

U—Usual; S—Sometimes; O—Not present

Disease	Shape of Vertebral Body						Bone Production	Intervertebral Disc					General Atrophy of Spine	Fragmentation	Appendage Affected	Subluxation	Other Manifestations	Remarks
	Complete Destruction	Triangular	Wedged	Uniform Narrowing	"Fischwirbel"	Normal Irregular		Normal	Widened	Uniform Narrowing	Triangular	Absent						
Congenital disease																		
Klippel-Feil syndrome	Absence		S				O	U					O	O	U	O		Other congenital abnormalities
Supernumerary vertebra			U				O	U		S			O	O	O	U		
Fusion						U	O					U	O	O	O	O		
Developmental																		
Retropulsion of nucleus pulposus			U				O				U		O	O	O	O	O	
Kyphosis dorsalis juvenilis		S	U				O	U					O	O	O	O	S	Köhler's disease, etc. Most of spine
Osteochondritis						U	O	U					O	O	O	O		
Presenile osteoporosis			S		U		O	U	S				Moderate	O	O	O	O	
Chondrodystrophy			S		U		O	U	S				O	O	O	S	U	
Trauma																		
Fracture			U				U	U					O	O	S	S	O	Compression only
Kümmell's disease			U	S			S	U					O	O	O	O	O	
Infections																		
Osteomyelitis	S	S	U			S	U			U			O	O	S	O	O	
Tuberculosis central	S	U	S				O	U			S	S	O	O	S	O		Usual involvement of neighbor
Tuberculosis epiphyseal		S	U			S	O				U	S	O	O	S	O		
Syphilis				U			O	U					O	O	O	O	O	
Charcot			U				O	U					O	U	O	S	O	
Fungus			U			S	U			S			O	U	U	O	U	Ext. fistula
Echinococcus	S		U				O	U					O	O	O	O	S	
Metabolic																		
Hunger				U	S		O	U					O	O	O	O	O	General bone affection
Osteomalacia				U	U		O	S	U				U	O	U	O	U	
Osteitis fibrosa cystica				S	U		O	U	S				O	O	O	O	U	
Paget's disease				U	S		U	U					O	O	U	O	U	
Acromegaly				S	U		O	U					O	O	O	O	U	

| | | |

The metastases may be of the osteoclastic or osteoblastic variety. In neither case does collapse take place early, even later though, in the osteoblastic type. When collapse does occur, there is a uniform narrowing of the vertebral body; the intervertebral discs remain intact until very late in the disease; there is no bone reaction; there is no kyphosis. Usually, there is seen in the other vertebrae, circular ragged defects in the medulla, spreading to the cortex. In the osteoblastic variety, there is a more or less uniform increase in density of the body without increase in size. When the latter appearance is present, it must be differentiated chiefly from Paget's disease and osteitis condensans. The former differentiation can often be made from the remainder of the skeletal system; the latter is extremely difficult. As far as can be determined from the literature and from our experience, osteitis condensans is not associated with collapse.

Involvement of the spine in Hodgkin's disease, arbitrarily described with tumors, is a common finding, so much so that a constant pain referable to the spine during the course of the disease leads one to believe that metastases are present whether they are demonstrated by the roentgenogram or not. Collapse, however, does occur with frequency and is then indistinguishable from that of carcinoma, in the appearance of the involved body. Usually, however, there are demonstrable metastases in only one or two vertebrae at a time. Lymphosarcoma does not ordinarily involve bone and a case with collapse has not been noted.

The various carcinomatous metastases, from lung, thyroid, breast, gastrointestinal tract, nasopharynx and prostate, as well as those from hypernephroma, neurofibroma and rhabdomyoma, when they cause deformity of the vertebral bodies, cannot be differentiated. Neurofibroma usually results in a marked kyphosis. It is merely a matter of probability that in any given case where the metastases are osteoblastic, in a male, the prostate should be suspected as being the site of the primary lesion, whereas the presence of collapse with osteoclastic areas suggests the probability of hypernephroma or breast carcinoma.

Pressure Atrophy. Paravertebral pathological conditions do not usually cause collapse of vertebrae. Aneurysms may cause marked pressure atrophy without any definite change in the size or shape of the vertebral bodies or the intervertebral spaces. The outlines are usually well made out but there is a marked decalcification of the body. This is also true in paravertebral sarcomas. After removal of such tumors, there is usually complete regeneration of the vertebral body.

DISCUSSION

It is needless to impress roentgenologists with the necessity for studying the normal appearance of the spine at various ages. Suffice it to make the following criteria:

In the normal vertebra, two systems of bone trabeculae are noted, which intersect perpendicularly and which are interrupted in their continuity by a sagittal canal carrying the main central vein of the body. Each caudally following vertebra is larger than, or at least of the same size as, that of the one above it. A longitudinal diameter of a vertebra shorter than the corresponding diameter of the vertebra above it is to be considered as absolute indication of a pathological involvement of the vertebra. Integrity of the sharpness of the outline and the uniformity of density of a vertebra are of utmost importance. This applies just as well to the intervertebral disc. It is essential to study small sections of the spine at a time, to use cones, compression and proper angulation; the routine use of stereoscopic anteroposterior views as well as the lateral view is advised. In short, complete and technically satisfactory examinations are necessary. The mechanism of the various types of vertebral deformity is to be made the subject of a further communication, where an attempt will be made to offer a rational explanation of why deformity occurs in the way it does in any particular disease. In Table 1 are summarized the

characteristics of the diseases mentioned in the present article.

CONCLUSIONS

A review of the literature and our own studies indicate that spinal deformity may occur in numerous conditions. In general, it may be said that such a deformity should be studied particularly with regard to the shape of the intervertebral discs, the presence of bone reaction, the presence of general atrophy of the spine and the manifestations of disease elsewhere. The fact must again be emphasized that diagnosis from a roentgenogram is impossible without, in addition, complete clinical data and correlation.

Thanks are due to Dr. Leopold Jaches for his personal inspiration and advice and for permission to use the departmental material. Thanks are also due to Mrs. L. B. Zeisler for her technical assistance.

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Vol. XXX, No. 2

CALCAREOUS CONCRETIONS IN RAYNAUD'S DISEASE

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MULTIPLE subcutaneous calcareous deposits ("interstitial calcinosis") have been described as being associated with a number of diseases. Particularly in connection with scleroderma and sclerodactylia, these deposits have been reported with increasing frequency in recent years. Such an association with Raynaud's disease has been less frequently observed.

Apparently the earliest report was by Lewandowsky[6] in 1905. A farmer's wife, aged fifty-seven, had had asphyxial paroxysms in the fingers of both hands for five years, nodules in the right forearm and around the right elbow for two years, and thickened, immobile skin over the fingers, with limitation of joint motion, for an unstated period. Although Lewandowsky speculates at some length on the cause of the phenomenon, he makes no mention of either Raynaud's disease or sclerodactylia.

In 1911 Davis[1] reported the case of a white woman, aged thirty-four, who had had Raynaud's disease for "many years," sclerodactylia and calcareous nodules for the past eight years. The deposits were found in the fingers of both hands and around one elbow.

Hunter's[4] patient, a white housewife, aged thirty-eight, had had Raynaud's disease since the age of fourteen, scleroderma involving hands, forearms, face, neck, back, and buttocks since the age of eighteen, calcinosis since the age of twenty-one. Concretions were present around interphalangeal and metacarpophalangeal joints, as well as in the region of the left olecranon.

Weissenbach et al[8] report the case of a woman who had had Raynaud's disease for fifteen years and sclerodactylia for three years; for five or six years she had had nodules over her knees, discharging through ulcerations soon after they developed. Chemical analysis of these nodules showed them to be composed chiefly (80.8 per cent) of organic matter, and roentgen studies were entirely negative.

Garcin et al[3] report the case of a married woman, aged sixty-five, who had had typical attacks of local syncope since the age of eighteen, but no asphyxial stage until the menopause, and no history of scleroderma or sclerodactylia except during the past nine years. During the past five years she had discharged concretions from the fingers of both hands. Nodules were excised for histological and chemical examination. All were in the subcutaneous layer of connective tissue; none represented thrombosis or atheromatous change of arteries or veins.Some gave the histological appearance of hyalin; chemical analysis showed them to be composed chiefly of organic matter. Others appeared to be calcified, and chemical analysis yielded chiefly calcium carbonate and phosphates. On the basis of these data Garcin and his coworkers offered the hypothesis that areas of ischemic necrosis results from the paroxysms of vasoconstriction, the necrotic areas becoming hyalinized and later calcified.

It will be noted that in all of the above cases the presence of scleroderma complicated the picture. In one instance the nodules preceded sclerodactylia, in one they appeared concomitantly, and in two they followed scleroderma. In the remaining case the duration of sclerodactylia is not stated. Three cases are cited below in which no scleroderma is described.

Logan[7] demonstrated by roentgenograms nodules in all the fingers of both hands in a woman, aged twenty-five, who had had chilblains of hands and feet as long as she could remember.

Lehrnbecher's[5] patient developed Raynaud's disease in the fingers at the age of eighteen, in the toes at the age of twenty-nine, and nodules in the fingers of both hands and near the left olecranon at thirty-five. These concretions were extruded through ulcerations, and after several months very few were seen in roentgen studies; during this time the patient had shown marked clinical improvement under treatment.

Weissenbach et al[9] report the case of a woman, aged forty-one, who first developed Raynaud's disease at the age of fifteen, and had had digital concretions since the age of twenty. In addition to these, roentgen exami-

nation also showed slight atrophy of some of the terminal phalanges, a finding not uncommon in Raynaud's disease. Chemical analysis of the nodules yielded about 75 per cent calcium carbonate and phosphates.

The following case is added to the group presenting the typical Raynaud picture,

Fig. 1.

with calcareous concretions but without scleroderma or sclerodactylia:

C.E.G., a white, Gentile, rural housewife, aged fifty-six, entered the hospital May 26, 1932, with a complaint of aching of the fingers of over thirty years' duration and repeated ulceration of four years' duration.

Family and past history were irrelevant. The patient denied use of alcohol, tobacco, or drugs. She had never been pregnant, although married twenty-five years.

Twenty-two years ago the patient's finger first became white when exposed to cold. This started in the left ring finger, gradually involving other fingers until within ten years all were affected. Meanwhile a similar but less marked disturbance was appearing in the toes. Normal color could always be restored by dipping the affected parts alternately in hot and cold water.

After several years the local syncope was followed by a period of asphyxia, and for the past five years this has come on directly without any preliminary syncope. During the past four years painful, tender, burning ulcers have appeared on all the fingers of both hands, crusting and discharging thick, stringy pus and sometimes small, stony bodies. All the ulcerations have healed with cicatrization, but secondary ulcers have appeared on several fingers. There have been marked blueness, swelling, and pain in all the fingers, redness of the hands, edema extending to the elbows, and aching pains radiating to the shoulders. In the legs there have been blueness and pitting edema to the knees, and painful, cold, blue toes without ulceration.

Physical examination revealed a fairly well developed and nourished white woman with an abnormally dry skin. Blood pressure was 140/80. Head, ears, eyes, nose, mouth, teeth, throat, chest, lungs, abdomen, pelvis, spine and reflexes were essentially negative. The heart was of normal size, rate 90–100, rhythm regular. A soft systolic murmur was heard at the apex.

All toes were cold and of a deep blue color; the legs were mottled blue up to the knees, with moderate pitting edema around the ankles. All the fingers were blue and swollen; the skin was dry, horny, slightly thickened, but freely movable on the subcutaneous tissue, which was not hard. There was no limitation of or pain on flexion or extension at any joint. All the fingers showed scars of old ulcerations; yellow crusts were seen and hard nodules could be felt in the left index finger and the right thumb, middle and little fingers.

Routine blood and urine studies were negative, as were the Wassermann and Hinton reactions. Basal metabolism was −18 at the only determination done.

Skin temperatures in all four extremities showed a satisfactory response to novocaine injection of peripheral nerves and the appropriate ganglia. Bilateral lumbar sympathetic neurectomy gave complete symptomatic relief in the lower extremities and restored normal color and temperature.

Roentgen Examination. Films of the left hand obtained shortly after admission showed conical atrophic terminal phalanges, with multiple areas of increased density in the subcutaneous tissue around these phalanges. In the right hand there was no definite atrophy of the phalangeal tips, but there were multiple areas of increased density in the subcutaneous tissue on the flexor surface of the terminal phalanges of the thumb, middle finger, and little finger (Fig. 1). Films of the feet showed some atrophy of the

terminal phalanges but no areas suggesting calcareous concretions. Over the left tibia were several small round areas of slightly increased density, interpreted as phleboliths. Roentgen study was otherwise negative.

COMMENT

From a roentgenologic standpoint, the following features are of some interest:

1. The fact that these concretions show varying degrees of density, some of them not even being opaque to the roentgen rays, is a point in favor of Garcin's suggestion that the nodules are islands of necrosis, resulting from ischemia, which become hyalinized and later calcified.[3]

2. The predominance of the calcareous deposits in the fingers, particularly in those fingers most severely afflicted with paroxysms of syncope and asphyxia, as noted by several observers, also favors Garcin's hypothesis. On the other hand, it is difficult to reconcile his explanation with the occasional occurrence of nodules around knees and elbows when these areas are not clinically involved. Moreover, one would expect concretions to be found in the toes; such a finding has not yet been reported.

3. The size of the deposits argues against the possibility that they are areas of calcification in the small arteries and veins of the fingers.

4. Roentgenographic demonstration of multiple dense areas in the subcutaneous tissue is a striking but not an early finding, and hence of no great value in diagnosis. Clinical symptoms and signs are present years before.

5. Finally, the conclusion of Edeiken[2] that "sclerodactylia is the only condition which will give the roentgenologic picture of calcareous deposits in the finger-tips combined with bone absorption of the tips of the phalanges" seems unwarranted. The same roentgenologic picture may be present in Raynaud's disease.

SUMMARY

Multiple subcutaneous nodules are occasionally found in Raynaud's disease with or without scleroderma; when present they frequently contain a large percentage of calcium salts and are demonstrable roentgenographically. Such deposits have been described in the fingers, around the elbows, and around the knees. Eight cases from the literature are briefly reviewed and a new case added.

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THE GENEALOGY OF THE ROENTGEN RAYS

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"In the history of Science, nothing is more true than that the discoverer, even the greatest discoverer, is but the descendant of his scientific fore-fathers; he is always essentially the product of the age in which he is born."

(Sylvanus P. Thompson, The Roentgen Society, London, Nov. 5, 1897).

LATE in October of 1895, Professor W. C. Roentgen, who was at that time the director of the Physical Institute of the Würzburg University, decided to experiment with cathode rays. The brilliant research work of Hertz, Lenard, and others, had revealed many new and interesting phenomena which suggested to him the probability that there were still many unsolved problems in connection with these experiments.

Roentgen set up his apparatus in one of the smaller laboratories of the Physical Institute of the University. This apparatus was similar to that then in use in many physical laboratories and lecture rooms all over the world. It consisted of a Ruhmkorff induction coil with a mercury interrupter and a Hittorf-Crookes tube. This simple apparatus was based on principles developed during three centuries through the labor of many students and ingenious investigators, including such men as Gilbert, Torricelli, von Guericke, Boyle, Hauksbee, Abbé Nollet, Franklin, Galvani, Volta, Oerstedt, Ampère, Ohm, Faraday, Henry, Plücker, Hittorf, Crookes, Hertz, Goldstein, Lenard, and many others. It was a simple apparatus, and yet it was destined to become the tool used to discover a phenomenon which will stand forever as the cornerstone of the proud structure of roentgenology which has since been erected by the natural and medical sciences.

In order to evaluate properly Roentgen's discovery of x-rays it is necessary to review the work of his "scientific fore-fathers," as they are called by Sylvanus P. Thompson, the English physicist and an enthusiastic admirer of Roentgen. In tracing these scientific forefathers, it is necessary to go back in ancient history to Thales of Milet, and to Theophrast. The former in 600 B.C. and the latter in 321 B.C. independently observed that friction caused amber to attract light bodies and therefore discovered the first "electric" phenomenon. These observations were entirely forgotten but they were re-discovered in the Middle Ages and this re-discovery was the real birth of present-day knowledge of electricity and of magnetism.

One of the first and fundamental contributions to the study of electricity was made by William Gilbert (1540–1603) (Fig. 1) who was born in Colchester, Essex County, England, on May 24, 1540, the brilliant son of Jerome Gilbert, a recorder of archives. He studied in St. John's College at Cambridge University and in 1569 he took the degrees of A.B., M.A., and M.D. He then became a Senior Fellow of St. John's College and afterwards a well-known physician; he was appointed Royal Physician to Queen Elizabeth of England. In 1600, at the age of sixty, he was elected president of the Royal College of Physicians after he had held several offices in that society. In addition to his numerous professional duties, Gilbert devoted many hours to research work and after eighteen years of hard work, he published his famous work under the title "De Magnete, Magneticisque Corporibus, et de Magno Magnete Tellure; Physiologia Nova, Plurimis & Argumentis, & Experimentis Demonstrata. Londini, Excudebat Petrus Short, Anno 1600" (Of the magnet, magnetic bodies, and of that great magnet, the earth, the new physiology, set forth by many

arguments and experiments) (Title page, Fig. 2), in London, and later in many other cities (Stettin 1628, Editio Secunda, 1633; Frankfurt 1629, 1638). He dedicated this book to those ". . . who not only in books but in things themselves look for knowledge." This treatise was recognized throughout the civilized world as authoritative information on magnetism and "electrical" observations and formed the real scientific foundation of subsequent investigations of electricity and magnetism. Gilbert was one of the first scientists to become dissatisfied with the lack of logic and system in the "experiments" of the alchemists, and emphasized the importance of accurate and detailed observations and information. He said once, "There are many books about hidden, abstruse and occult causes and wonders . . . words alone, without experimental proof. All of my own experiments were repeated again and again under my own eyes."

Gilbert studied the lines of force, or "effluvia" as he called them, around a small magnetic needle which was balanced upon a pivot. In performing these experiments he discovered magnetic induction and magnetic conductivity and many other similar phenomena. He also perceived that the ordinary magnetic compass needle points toward the north because the earth is a great magnet and not because the needle is "attracted by the stars." He therewith discovered terrestrial magnetism. In order to study the distribution of this magnetism, he experimented with a magnetic needle upon his "terrella" (Fig. 3) which was a large sphere of loadstone, the Neo-Latin name for which he originated.

Gilbert re-discovered the frictional electricity and the "electrical" properties of amber which were known from ancient times, and in addition he found a series of other materials such as sulphur, glass, resin, sealing wax and many crystals which,

Fig. 1. William Gilbert (1540–1603).

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SIS, MEDICI LONDI-
NENSIS,

DE MAGNETE, MAGNETI-
CISQVE CORPORIBVS, ET DE MAG-
no magnete tellure; Physiologia noua,
plurimis & argumentis, & experimentis demonstrata.

LONDINI
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Fig. 2. Title page of Gilbert's "De Magnete."

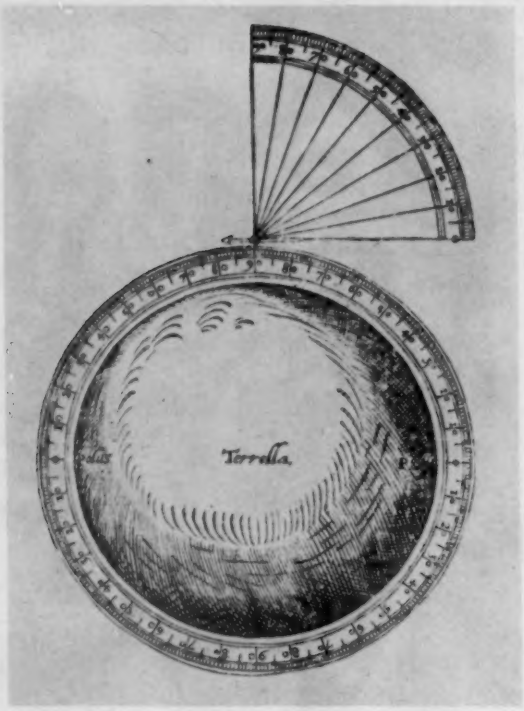


Fig. 3. Gilbert's "Terrella."

when rubbed, also possess "electrical" properties. Gilbert was the first one to use in his writings the term "electrical" when he says "vim illam electricam nobis placet appellare, quae ab humore provenit." He also found that, unlike metals attracted by a magnet, the materials mentioned before when rubbed attract only small particles and also leave the attracted particles unchanged. He studied the behavior of rubbed bodies at various temperatures, degrees of humidity, etc. Gilbert explained these differences between the effects of the magnet and rubbed resin on the basis of his "effluvia" theory: "The difference between magnetics and electrics is that all magnetics run together with mutual forces; electrics only allure," a theory which was considered correct for many years. He thought that electrical attraction took place in the same manner as the attraction of cohesion. Two electrified bodies act upon each other by means of their "effluvia," excited by friction. Curiously enough, he did not observe electrical repulsion. Nicolaus Cabaeus, a Ferrara Jesuit (1585–1650), was the first to record the phenomenon of electrical repulsion in 1629. To measure electrical attraction Gilbert devised a kind of electroscope which he called a "versorium." It consisted of a thin metal needle suspended in a horizontal plane so that it "could be attracted like a compass needle."

Gilbert's experiments were of fundamental significance. He was not only the first, but was also one of the most successful investigators in the field of magnetism and electricity. Queen Elizabeth acknowledged the significance of his work and granted him an annual pension for his philosophical studies. Gilbert died on November 30, 1603, from the plague. He is buried in Colchester, where his monument still stands in the Holy Trinity Church.

LEZIONI
ACCADEMICHE
D' EVANGELISTA
TORRICELLI
Mattematico, e Filosofo
DEL SERENISS. FERDINANDO II.
GRAN DUCA DI TOSCANA
Lettore delle Mattematiche nello Studio di Firenze
E ACCADEMICO DELLA CRUSCA.
IL PIV BEL FIOR NE COGLIE
IN FIRENZE M. DCC. XV.
Nella Stamp. di S. A. R. Per Jacopo Guiducci, e Santi Franchi.
Con Licenza de' Superiori.

Fig. 4. Title page of Torricelli's "Lezioni."

After his death Gilbert's brother, who had the same name, published his brother's latter work in Amsterdam in 1651 under the title "De Mundo Nostro Sublemari Philosophia Nova." Priestly said of Gilbert's work in his famous book "The History and Present State of Electricity, 1767": "Such were the discoveries of our countryman, Gilbert, who may justly be called the Father of electricity, though it be true that he left his child in its very infancy." Another Englishman, Dryden, spoke in similar vein about the great value of Gilbert's work a hundred years after its publication, "Gilbert shall live till loadstones cease to draw, or British fleets the boundless ocean awe." Lord Kelvin called Gilbert's work, "One of the finest examples of inductive philosophy that has ever been presented to the world." Gilbert's experiments had without doubt a highly beneficial influence upon the work of his contemporaries and successors. He bequeathed his famous collection of instruments, globes, minerals and books to the College of Physicians, but his collection unfortunately was destroyed in the great London fire of 1666.

Since we are particularly interested in the work of Roentgen's "scientific forefathers" we must limit our discussion to those successors of Gilbert who worked on problems of magnetism and electricity and whose work eventually led to the development of the high tension apparatus which the Würzburg savant used in the nineteenth century in his experiments. But we also must review the numerous attempts to create an "empty space" which eventually led to the construction of the vacuum tubes which formed such an important part of the armamentarium of the Würzburg physicist. The development of these apparatuses often went hand in hand, and many a scientist worked at the same time on the improvement of some electrical apparatus and on the creation and perfection of high vacuum tubes.

The Italian, Evangelista Torricelli (1608–1647), was among those who first attempted to create an "empty space," that is, to investigate the basic principles of removing air from an air-tight vessel, and thus he contributed to the development of the evacuated glass tube. Torricelli was born in Firenza. At the age of nineteen he

Fig. 5. Otto von Guericke (1602–1686).

was sent to Rome to study mathematics and mechanics. One of his teachers, Castelli, sent him to the great scientist, Galileo Galilei, after he had developed a theory for the explanation of some of Galilei's experiments; Torricelli worked with the blind Galilei for the last three months of the great scientist's life. He then was appointed successor to Galilei as Professor of Mathematics and Mathematician at the Academy of Florence under the patronage of the Prince Ferdinando II of Tuscany. He discovered the mercury barometer in 1643, and in working with it found in a 46-inch tube the vacuum at the top of the mercury column which subsequently was called the "Torricelli vacuum." The announcement of this important discovery

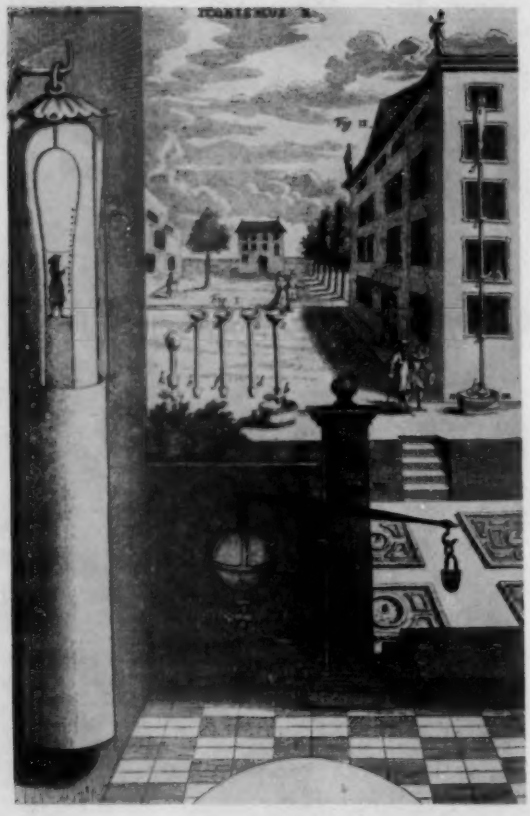


Fig. 6. Von Guericke's barometer.

was made in two letters written to his friend Ricci. The discovery of the Torricelli vacuum removed the conception of the "horror vacui" i.e. nature's abhorrence of a vacuum, which had existed for centuries. Torricelli died from pleurisy in Florence in October, 1647, at the early age of thirty-nine.

It was not until 1715, almost three-quarters of a century later, that the two famous letters which he had written to Ricci, and a description of his experiments and discoveries were first published by Tomasso Bonaventuria in Florence under the title "Lezioni Accademiche." (Title page, Fig. 4.) Torricelli's observation of the influence of the atmospheric pressure, especially that the barometric pressure becomes less at increasing distance from the center of the earth, was soon proved to be correct by the French philosopher and mathematician, Blaise Pascal (1623–1662), who, on September 19, 1648 (one year after Torricelli's death), asked his brother-in-law, Perrier, to carry a Torricelli barometer to the top of the Puye de Dôme in the Auvergne, a mountain 974 meters high. The barometric pressure on top was considerably less than that at the foot of the mountain. Pascal himself, who was lame, repeated the experiment on a small scale on one of the city gates in Paris.

About the same time, Otto von Guericke (1602–1686) (Fig. 5) devoted himself to the study of similar problems. He was born on November 20, 1602, the son of an old Magdeburg family. He studied law in Leipzig, Jena and Leyden. At the latter university he was also attracted by lectures on physics and mathematics. Later he found time enough for research in spite of his

Fig. 7. Air pumps on title page of von Guericke's book.

strenuous administrative activities in the city of Magdeburg which had been completely destroyed in the Thirty Years' War. Von Guericke was a very gifted investigator and was one of the first to break with the old scholastic school. "Oratory, elegance of words, and fluency of debating are of no value in natural sciences" were his words and he attempted to answer by experiment many scientific questions. Yet the debates of the philosophers on the existence or non-existence of a vacuum aroused his interest and soon he worked on an apparatus to create a vacuum. He started out to work on the principle of the barometer and built himself a water barometer 60 feet high outside his house. He placed a small wooden figure on the top of the column of water in the barometer, the out-stretched hand of which pointed to a scale to indicate the barometric pressure, thus predicting changes in the weather (Fig. 6). This ingenious apparatus brought the inventor into disrepute as a sorcerer. Without knowledge of Torricelli's work, von Guericke made many experiments similar to those of the Italian scientist. It was not until 1654 that the monk Valerianus at the Reichstag of Regensburg called von Guericke's attention for the first time to Torricelli's experiments.

Soon the barometric experiments were followed by attempts to create an "empty space" in a different manner. About 1646 von Guericke constructed his first real air pump and in 1663 he made considerable improvement on his first crude apparatus (Fig. 7). The improved pump consisted of a vertical cylinder in which the piston could be moved up and down by means of a lever. An automatic leather valve replaced the stopcock which he used on his first apparatus. He also attempted to obviate the disagreeable properties of the "dead space." Von Guericke made many demonstrations of how an "empty space" might be produced and of the tremendous atmospheric pressure upon an evacuated container. His best known experiment is that of the "Magdeburg hemispheres," which was demonstrated to Emperor Ferdinand III and the Princes who had assembled at the Reichstag in Regensburg in 1654 (Fig. 8). At that time he illustrated the outside air pressure on the evacuated hemispheres which were about 20 inches in diameter by showing that two teams of eight horses were unable to pull the hemispheres apart, but as soon as air was admitted to the evacuated space, the hemispheres fell apart.

It is of interest to note that after the Regensburg meeting some of von Guericke's original apparatus was taken to Würzburg, and that the report of the experiments was publicly made known by his friend Caspar Schott in his "Mechanica Hydraulica-Pneumatica Experimentum Novum Magdeburgicum, 1657," and later on in "Technica Curiosa, 1664," and that it was from this same city that the news of the discovery of the roentgen rays was given out some two hundred years later. In his inaugural speech as Rector of the Würzburg University in 1894, Professor Röntgen called attention to Caspar Schott who was one of his predecessors in the chair of physics at the Würzburg University.

"Caspar Schott was born in 1608 in Königshofen. He studied in Würzburg, but being a Jesuit, he was forced to flee before the invasion of the Swedes and found a position as teacher in Palermo. About 1655 he returned to Würzburg as Professor of Mathematics at the Gymnasium which at that time was connected with the University and he kept this position until his death in 1666. Schott followed in the footsteps of Kirchner who was his teacher, but he limited his studies to physics, mathematics and some medical subjects, the results of which were published in ten voluminous tomes. These publications made his name famous, though they contained very few important discoveries or original investigations. 'Mechanica Hydraulica-pneumatica' is one of most interest to physicists and was published in 1657. It is the first description of the extremely important invention of the air pump which was made about 1646 by Otto von Guericke, the Burgomeister of Magdenburg. The air pump of von Guericke and the

barometer of Torricelli were of fundamental importance because the investigations on the properties of various gases which soon followed were dependent upon them. It was really Schott's book which caused Boyle, the English physicist, to initiate his important experiments on the elasticity of atmospheric air. Schott was the father confessor of Prince-Bishop Johann Philipp von Schoenborn who was one of the most intelligent and most active princes of his day. He had seen the experiments which von Guericke demonstrated in 1654 before the Princes at Regensburg. He was convinced of the importance of the discovery but was too impatient to await the construction of new apparatus, so he bought the whole collection of von Guericke and transported it to Würzburg. The experiments were then demonstrated to the Professors and invited guests. It was on this occasion that Schott first saw the air pump and was permitted to use it for his own researches. Schott was probably the first to investigate the influence of various atmospheric pressures upon animal life. These observations were his only contributions of importance. He could not convince himself that the old, erroneous idea of the 'horror vacui' had come to an end and he even seriously tried to defend this idea against von Guericke."

The publications of Schott, as well as the communications which went from mouth to mouth, made the work of von Guericke well known long before von Guericke himself finished a report of his results in March, 1663, and recorded them in seven books which were dedicated to the Grand Elector. The title of these books was "Ottonis de Guericke, Experimenta Nova (ut vocantur) Magdeburgica de Vacuo Spatio" (Fig. 7). However, this work was not printed until 1672 in Amsterdam due to the illness of the author and to the difficulty in finding a publisher. Even then, von Guericke did not receive a fee for his work, though he had spent about 20,000 thaler for his experiments. The publisher

Fig. 8. Demonstration of von Guericke's Magdeburg hemispheres.

hesitatingly gave him only a few free copies.

Other experiments of von Guericke must also be mentioned because they formed the basis for the construction of the electrical apparatus which later played such an important rôle in the discovery of the roentgen rays. Von Guericke constructed an electrical machine which consisted of a rotating sulphur sphere against which he pressed one of his hands. The sphere had been made by pouring sulphur into a glass globe which was broken away after the sulphur hardened. The rotation of the sulphur sphere with the dry hand pressed against it, yielded static electricty of a potential high enough to produce phosphorescent light and brush discharges, or even small sparks. Such sparks, which actually were the forerunners of electrical illumination, were observed first by the philospher Leibniz in 1672, while using a von Guericke apparatus, but to von Guericke belongs the credit for first having observed electric light phenomena.

Von Guericke, stimulated by Gilbert's book, studied many electric phenomena with his apparatus, such as attraction and repulsion, which latter appearance he observed for the first time—independently of the monk Cabaeus—conductivity, the effect of sharp points on static electricity, etc. He thereby established many of the fundamental principles for the static machine which was developed later and which was based on these observations. It must be stated, however, that, like Gilbert, von Guericke sometimes speculated beyond the realm of fact. For instance, he believed that the earth was a great electrical machine which produced electricity by the friction of the rays of the sun while being turned "by the hand of the Almighty."

The electrical experiments of von Guericke did not cause the same sensation that his vacuum experiments had created. His later years generally were saddened by the ingratitude of his fellow citizens whose narrow-mindedness made them unappreciative of the tremendous work which he had been doing for his home town. He gave up his Magdeburg office in 1681 and died at the home of his son in Hamburg five years later, on May 11, 1686, at the ripe age of eighty-four.

Fig. 9. Robert Boyle (1627–1691).

Von Guericke's experiments created great interest and were repeated in many places. A contemporary scientist, the Englishman, Robert Boyle (Fig. 9) who was born at Lismore, in 1627, and died in London, in 1691, carried on similar investigations. Boyle was one of the founders of the "Invisible College" which later became the "Royal Society of London for Improving Natural Knowledge." He declined, however, the presidency of this Society in 1680, for religious reasons. Boyle was successful in solving many important physical and chemical problems. He acquainted himself with most of von Guericke's experiments from the publications of Caspar Schott as well as through personal communications. With his assistant, Robert Hooke, he improved von Guericke's air pump or "pneumatic engine" as he called it, and added

the pinion movement to it. The result was the improved pump "Machinae Boyleana" completed in 1659, which was followed later by still more improved types by Hooke and Papin and by Boyle himself. With these machines, Boyle repeated the experiments of Torricelli and Pascal, and studied the behavior of gases when enclosed in glass tubes and made many important observations. The gas law which bears his name, and which he formulated in 1661, is well known. He published many of his results under the title "New Experiments, Physico-Mechanical upon the Electricity and Weight of Air and their Effects," in 1659, which was long before von Guericke's book appeared. Boyle in 1676 made the important observation that electrostatic effects of rubbed amber and magnetic effects were also effective in a vacuum. His numerous experiments connected with his observation appeared in another important publication, "Experiments and Notes about the Mechanical Origin or Production of Electricity, 1675," in which he not only described many of his experiments on electrical attraction but also discussed the various hypotheses on electricity which were current at that time, notably those of Cabaeus, Browne, Gassendi, Carterius, and others.

Boyle came from a prominent family. His father, Richard Boyle, later became the Earl of Cork and was a good friend of Cromwell. Young Boyle was one of fifteen children. As was customary in those days, he traveled extensively in Europe during his early manhood and was in Florence at the time of Galilei's death. He was rather frail and had to take good care of his health. At the age of twenty-eight he settled in Oxford and devoted his entire time to his scientific and religious studies. He died in December 31, 1691, and was buried in the Abbey. After his death all of his work was published in six volumes "Opera Omnia Philosophica et Chemica."

The great scientist, Isaac Newton, was born in Woolsthorpe on December 25, 1643, and died in London on March 20, 1727. In addition to other studies in electricity he also built in 1675 an electrical machine with a rotating glass sphere with which he made a large series of important experiments. An interesting observation made by him in the course of a cleverly arranged experiment was that one side of a glass plate chould be charged electrically by rubbing the other side with a cloth. Priestley in his book on "Electricity" in 1769 described this experiment of Newton's as follows: "Having laid upon the table a round piece of glass, about two inches broad, in a brass ring, so that the glass might be one-eighth of an inch from the table, and then rubbing the glass briskly, little fragments of paper laid on the table, under the glass, began to be attracted, and moved nimbly to and fro."

Newton sent an account of this experiment to the members of the Royal Society in 1675. After several failures, the attempts of the members to repeat the experiment were successful, and the Society formally returned its thanks to the great physicist.

Francis Hauksbee, the elder, who died in 1713, Curator of Experiments to the Royal Society and a countryman of Boyle and Newton, became very much interested in the experiments in electricity of these scientists as well as in those of Gilbert and von Guericke. He repeated many of them and built an electrical apparatus which was quite an improvement over von Guericke's sulphur sphere. He had discovered the electrical qualities of glass and therefore used a glass cylinder which was "turned by a winch and rubbed by hand." He improved it soon by using wool which rubbed against glass and later leather rubbing against amber. With these machines he discovered many new and curious phenomena, especially a variety of effects in regard to electrical attraction and repulsion and also electrical influence. Another phenomenon which he investigated with an electrical machine was an effect known under the name of "mercurial phosphorus." This effect consisted of a flickering lumines-

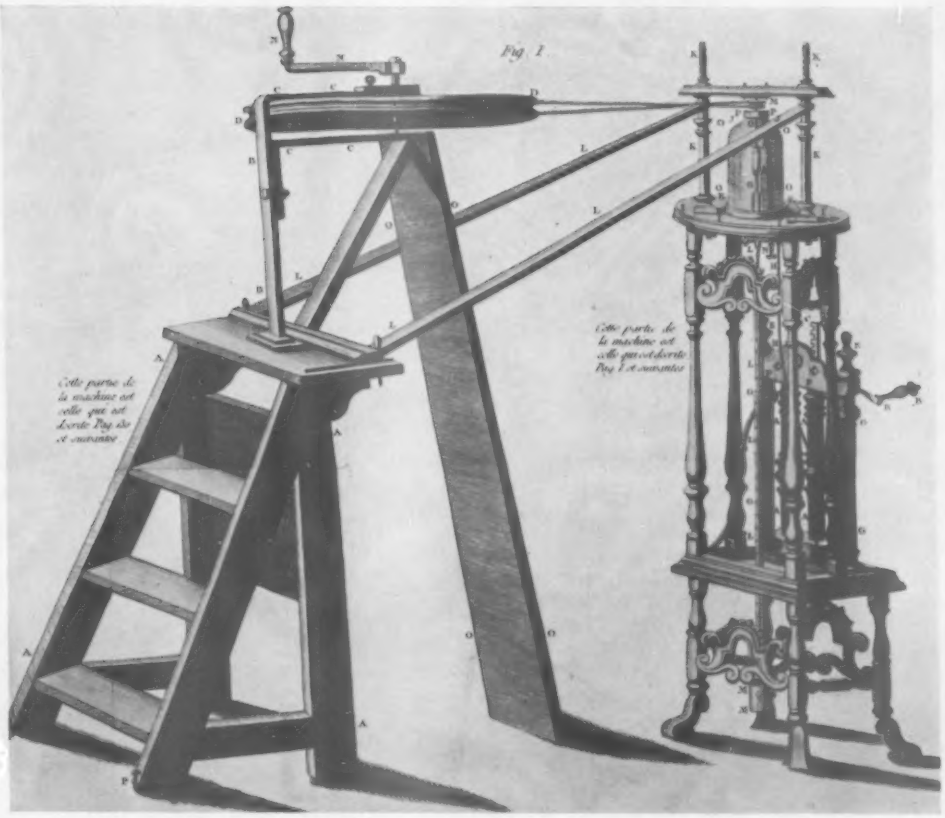
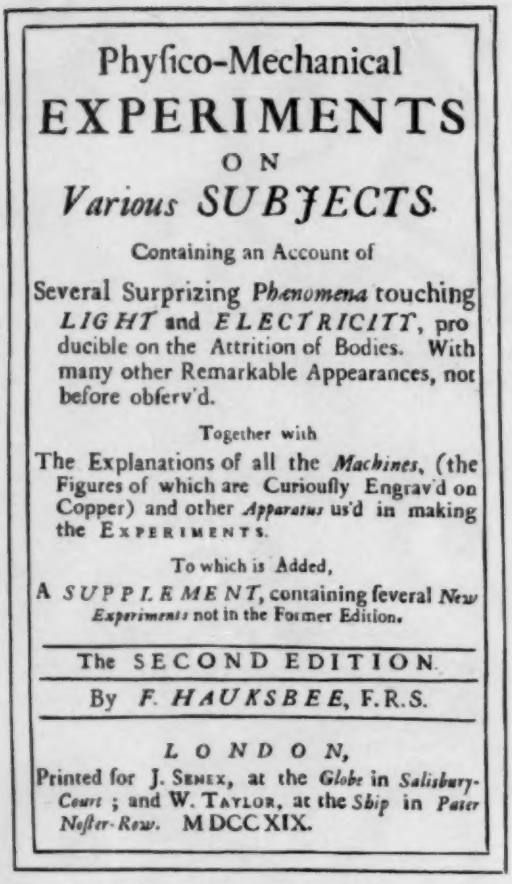


FIG. 10. Hauksbee's pump and electrical machine.

cence produced by shaking mercury in a so-called "shaking tube," i.e. an evacuated tube or a barometer. The French astronomer Jean Picard (1620–1682), a priest of Paris, had first observed this phenomenon while carrying a barometer in the dark to the Porte Saint Michael in Paris. Hauksbee suspected the luminescence as being of electrical nature though he did not realize that the glass of the tube was in any way related to the production of the "strange light." In working with his electrical machines he realized soon, however, phenomena which were very similar to the "mercurial phosphorus" and that they were due to the friction of the rubber or leather against the glass cylinder. He deducted from these observations that the mercurial phosphorus effect was similarly due to the friction of the moving mercury against the glass walls, but was under the impression that electricity came from an "electrical fire" enclosed in the bodies.

He proceeded a step further in studying these light phenomena, and following Boyle's suggestion made about 1676, placed the electrical machine in a bottle which could be evacuated (Fig. 10). For this purpose he built a double cylinder air pump with many improvements over the von Guericke-Boyle type. Many and various were the new observations made by Hauksbee with this new apparatus. He not only produced brush discharges and therewith many effects of "electrical light," but he also obtained sparks larger than had ever been seen before in a laboratory. "Sometimes," he said, "I have observed the light to break from the agitated glass like lightning, and if a hand is held near the fricated glass a light will be seen to dart from it with a noise like that of a green leaf in a fire,



Phyſico-Mechanical
EXPERIMENTS
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Containing an Account of

Several Surprizing *Phænomena* touching *LIGHT* and *ELECTRICITY*, producible on the Attrition of Bodies. With many other Remarkable Appearances, not before obſerv'd.

Together with

The Explanations of all the *Machines*, (the Figures of which are Curiouſly Engrav'd on Copper) and other *Apparatus* us'd in making the EXPERIMENTS.

To which is Added,

A *SUPPLEMENT*, containing ſeveral *New Experiments* not in the Former Edition.

The SECOND EDITION.

By *F. HAUKSBEE*, F.R.S.

LONDON,

Printed for J. SENEX, at the *Globe* in *Salisbury-Court*; and W. TAYLOR, at the *Ship* in *Pater Noſter-Row*. MDCCXIX.

Fig. 11. Title page of Hauksbee's Book, "Physico-Mechanical Experiments" (Second Edition).

but not so loud." Interesting in this connection is one special experiment made by Hauksbee and described by Priestley as follows: "He lined more than half of the inside of a glass globe with sealing wax, and having exhausted the globe, he put it in motion; when, applying his hand to excite it, he saw the shape and figure of all the parts of his hand distinctly and perfectly, on the concave superficies of the wax within. It was as if there had only been pure glass, and no wax interposed between his eye and his hand." After the discovery of the roentgen rays in 1895 this experiment was occasionally cited to prove that Hauksbee at his time had already produced a type of radiation "penetrating all parts of the hand."

Many other experiments were tried by Hauksbee with his static machine but the idea of separating the static generator from the vacuum tube did not occur to him and was not realized until many years later. And in spite of the fact that he was a most prolific experimenter, he did not form a clear conception of the power of electricity in general or of the "distinction of bodies into electrics and non-electrics." He attempted, for instance, to use a metal sphere instead of glass or sulphur in his electrical machine and explained his negative results by the fact that "a small attrition is not sufficient to put the parts of the metals into such a motion as to produce an electrical quality."

In 1709 he published part of his work in a book called "Physico-Mechanical Experiments on Various Subjects; Surprising Phenomena Touching Light and Electricity Producible on the Attrition of Bodies," and in 1719 his complete studies were published posthumously (Fig. 11). Hauksbee's excellent experiments on electricity were a most valuable confirmation and continuation of the theories and observations of his great countrymen, Gilbert, Boyle, and Newton. Hauksbee's birth date is not known; he first became known in 1704 and 1705 through his excellent experimental work presented to the Royal Society. He must have been born around 1680 for in 1754 M. de Bremond, who translated his "Physico-Mechanical Experiments" into French, remarks: "If one sees the great number of discoveries made by Hauksbee one would not think that he only worked for twelve or thirteen years."

The artificial production of sparks as demonstrated so beautifully by Hauksbee created quite a sensation all over the world. A contemporary of Hauksbee, William Wall, while working with Boyle in 1698 also noticed light and sparks while rubbing small pieces of amber against each other or by rubbing amber with wool. Wall compared these sparks and light with lightning and thunder when he said, "I got a pretty large piece of amber which I caused

to be made long and taper and drawing it gently through my hand, being very dry, it afforded a considerable light. The crackling is full as loud as charcoal on fire, and five or six cracklings, or more have been produced from one single friction, light always succeeding each of them. This produced light and crackling which seem in some degree to represent thunder and lightning." Wall must have had a peculiar conception of these experiments for he added, "The best time to carry out these experiments is when the sun is 18 degrees below the horizon." On account of his observations, Wall abandoned Gilbert's "effluvia" theory of electricity which even Hauksbee still upheld. Wall believed that electrical phenomena were in some way associated with light.

In 1720, another Englishman, Stephen Gray (1696–1736), a pensioner in the London Charter House and a very studious worker, found that electricity which manifested itself by "light and crackling noises" could be produced by rubbing hair, silk, linen, wool, paper, leather, wood, and other materials, from one body to another. He extended such experiments over a number of years and once said: "Although these effects are at present but in minimis it is probable in time there may be found out a way to collect a greater quantity of the electric fire, and consequently to increase the force of that power." In 1729, he made the important discovery that electricity could be conducted from one body to another through metallic wires or "non-electrics" as he thought. He was, therefore, the first to become aware of the difference between conductors and non-conductors. His first experiments in conductivity were made with a fishing rod and insulating glass rods; he succeeded in carrying the current a distance of 18 feet, and later as much as 34 feet. Together with his friend, Granville Wheeler, he then attempted to conduct the "electric virtue" through a hemp cord 800 feet long, but the experiment was unsuccessful until Wheeler had the idea to suspend the string on silk threads. The conductor thus becoming insulated, the attempt was crowned with success. They also found that the "electric virtue" could be communicated to their line of communication without touching it. Gray presented his results to the Royal Society in a paper entitled "The Electric Property of a Glass Tube may be Conveyed to other Bodies so as to give them the same Property of Attracting and Repelling Light Bodies as the Tube has when Excited by Rubbing; and that this Property may be Transmitted to Bodies which are a long way from the Tube." The importance of this work lies in the fact that electricity thus was shown to be able to exist outside of a body. Besides these important discoveries, Gray also investigated many other problems of static electricity. For example, he studied its distribution within a body and attempted to determine a possible relationship between electric and magnetic forces. He studied carefully the effect of electric influence which had been described by Hauksbee. He made an isolating "resin cake" by melting a mixture of sulphur, wood and sealing wax into a cake. This cake would hold an electrical charge for a long time when kept under a glass cover. Of one of these resin cakes, he constructed an "isolating chair" (1732) which he used in a number of startling demonstrations with Gray Friar lads who were seated upon the chair. For example, he caused an electric spark to shoot from the nose of one of them by touching his foot with a rubbed glass rod. Some of Gray's explanations of the phenomena found were not quite as ingenious as his experiments. He imagined, for instance, that the amount of "electric virtue" depended upon the color of the charged subject. He said that the body, if suspended on blue lines retained its power of attraction for fifty minutes, on scarlet lines for twenty-five minutes and on orange colored lines for twenty-one minutes. During his last years and even on his deathbed, Gray left the sound foundation of experiment and speculated in the realms of philosophy.

Fig. 12. Abbé Nollet (1700–1770).

Many of Gray's experiments were repeated by one of his contemporaries, Charles Francis de Cisternay du Fay (1699–1739), a Frenchman who was the director of the Royal Gardens in Paris and a member of the Paris Academy of Science. Du Fay's most important contribution to electrical science was the discovery in 1743 of the existence of two different types of electricity, the "vitreous" or "glass" and the "resinous" electricity. The former was produced when smooth glass, rocksalt or crystals were rubbed with silk, and the latter when silk or paper was rubbed with wool. Du Fay described this discovery in the following words:

"Chance has thrown in my way a universal and remarkable principle which casts a new light upon the subject of electricity. The principle is that there are two distinct kinds of electricity, very different from one another; one of which I call vitreous, the other resinous electricity. The first is that of glass, rockcrystal, precious stones, hair of animals, wool and many other bodies. The second is that of amber, copal, gum lac, silk, thread, paper and a vast number of other substances. The characteristics of these two electricities is, that they repel themselves and attract each other. From this principle one may easily deduce the explanation of a great number of other phenomena; and it is probable, that this truth will lead us to the discovery of many other things."

To prove the difference between these two types of electricity, du Fay constructed an electroscope which was similar to the "versorium" described by Gilbert. When this instrument was charged with glass electricity and then a rubbed resin rod was brought near it, the deflection of the filaments of the electroscope was decreased, and vice versa. He also could show that "communicated electricity" had the same properties as "excited electricity." Du Fay then went a step further and showed that all bodies, even metals, could be made "electric" by heating and then rubbing them; they must, however, be suspended on insulating silk threads in order to stop the electric charge from being dissipated. He furthermore introduced a series of improvements in the construction of electri-

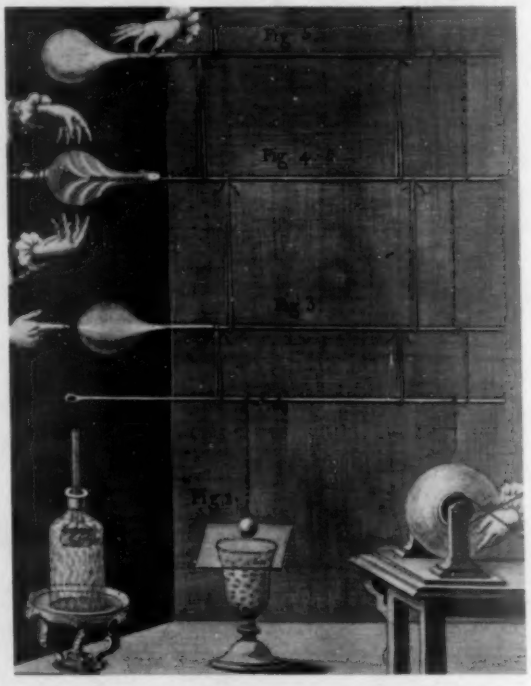

Fig. 13. Abbé Nollet's electrical machine and "egg."

cal apparatus. Du Fay had no satisfactory explanations for the important discovery of the two types of electricity and generally received more recognition in Germany than in his own country or in England. The last of his papers appeared in 1737 in the Memoirs of the Academy. He died of smallpox in Paris in 1739 at the early age of forty-one years. His many investigations were published in a series of memoirs which appeared in the transactions of the Academy in the years 1732 to 1737.

Another important advance in the knowledge of electricity was due to another Frenchman, Jean Antoine Nollet (1700–1770) (Fig. 12), who was the son of a farmer and became a member of the Royal Society and the French Royal Academy. Nollet, who had collaborated with du Fay in many of his experiments, became a teacher of science in the Royal House, an Abbé and Professor of Physics of the University of Navarre and teacher at the Artillery and Engineering School of Paris. Abbé Nollet carefully studied the work of

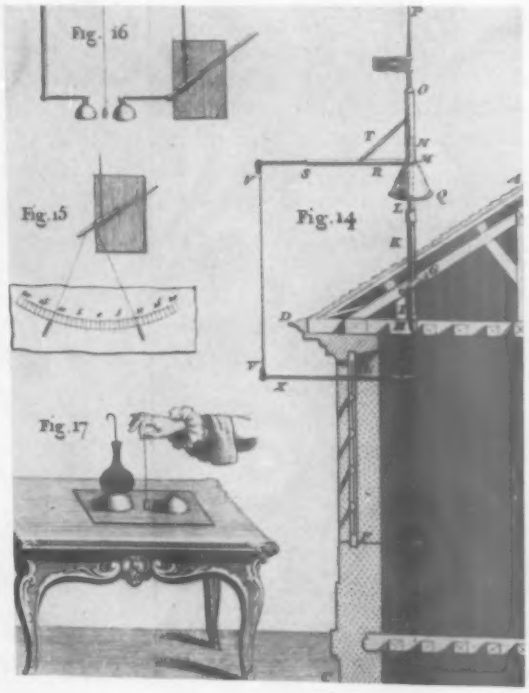

Fig. 14. Abbé Nollet's electrical experiments.

LETTRES
SUR
L'ELECTRICITE.

Dans leſquelles on examine les dernieres Découvertes qui ont été faites ſur cette Matiere, & les conſéquences que l'on en peut tirer.

Par M. PAbbé NOLLET, de l'Académie Royale des Sciences, de la Société Royale de Londres, de l'Inſtitut de Bologne, & Maître de Phyſique de M. LE DAUPHIN.

A PARIS,

Chez HIPPOLYTE-LOUIS GUÉRIN, & LOUIS-FRANÇOIS DELATOUR, rue S. Jacques, vis-à-vis les Mathurins, à S. Thomas d'Aquin.

M. DCC. LIII.

Avec Approbation & Privilége du Roi.

Fig. 15. Title page of Abbé Nollet's "Lettres sur l'Electricite."

von Guericke, Hauksbee, and others. He improved upon their experiments and instead of placing the source of the high tension within the evacuated vessel as Hauksbee had done, he placed it outside and led the high tension to the glass vessel by means of iron chains. He thus simplified considerably the apparatus for the study of the discharge through high vacuum (Fig. 13). The amount of electricity was measured by means of an electroscope which Abbé Nollet made by suspending two light strings that would separate when the instrument was charged (Fig. 14). The glass vessel with which he carried on his research was egg-shaped and it was therefore called the "electrical egg." This "electrical egg" was undoubtedly the fore-

runner of the Hittorf-Crookes tubes and therefore also of the roentgen-ray tube.

Abbé Nollet liked to demonstrate his electrical experiments to large audiences, because, as he said, "Some of these electric experiments were most successful if they were shown before many people, provided that they did not come too close in their effort to see the experiments and provided that they were not sweating so much that the glass became humid." His experiments and theories were published in a large series of books and papers. In these he expressed an idea that electricity was a highly inflammable liquid which could be lit by the smallest shock. One of Nollet's most important books bears the title "Recherches sur les causes particulières des phenomenes électrique." His well-known "Lettres sur l'Électricité" (Fig. 15) which were published first in 1753 are also of great interest. In the second edition of this communication he stoutly defends his theories against those of Benjamin Franklin as can be deduced from the complete title, "Lettres sur l'Électricité, dans lesquelles on examine des dernières dé couvertes qui été faites, and les Conséquences que l'on en peut tiré: où l'on soutient le Principe des effluences simultanes contre la Doctrine de M. Franklin, et contre les nouvelles Pretensions de ses Partisians." However, Franklin's theories ultimately proved to be built upon a firmer foundation than those of Abbé Nollet. A contemporary of Abbé Nollet, Desaguliers did much to clarify the confusion in the large number of electrical observations, and in June, 1742, won a medal of the value of 300 pounds given by the Academy of Bordeaux for an excellent essay on electricity.

Fig. 16. Benjamin Franklin (1706–1790).

Benjamin Franklin (1706–1790) (Fig. 16), the great American statesman and scientist, made many important contributions to the science of electricity. Franklin came from a large family and was the tenth son of the soap maker, Josiah Franklin, who migrated from England to North America, in 1765. From a lowly station in life, Benjamin Franklin became a printer, writer, owner of a printing establishment, publisher of a newspaper, secretary of the Colonial Department, a postmaster, and occupied other important positions in the Colonial government, and was also a scientist of note. In his spare time he studied what was known about electricity at the time and soon advanced many theories of his own. According to Franklin's opinion, electricity, "a subtle matter" penetrated all nature in extremely thin dilutions and a body became electrified on account of an accumulation or of a deficiency of this thinly distributed electricity. For example, he thought that when friction was applied to a glass sphere the "electric fire" was "pulled" out of the material with which the friction was applied, but when the friction was stopped, the glass sphere gave up the electricity to another body which contained less electricity. If electricity was accumulated the "vitreous" electricity of du Fay appeared; if there was a deficiency in electricity the phenomenon of "resin-

ous" electricity was produced. Franklin therefore used the two terms positive and negative electricity but was under the impression that only one electrical matter existed. Franklin's experiments and theories relating to atmospheric electricity during thunder storms, especially his proof that lightning is an electric discharge, are best known. The studies on the diminution of electricity by points led to the construction of the lightning rod. His son collaborated in the famous experiment with the kite which in June, 1752, was made as a proof of his theories of electricity in the atmosphere. This experiment confirmed an old opinion of his which he had expressed in a short note made on November 7, 1749, when he stated his belief that thunder and lightning were electric phenomena. A similar opinion had been ventured three years before by J. H. Winckler, Professor of Greek and Latin, of Leipzig.

Toward the end of 1745, the investigations of E. J. von Kleist, the Dean of the Cathedral, in Kammin, Pommern, became known. He had discovered the so-called "Kleist jar." In a letter to a friend on November 4, 1745, Kleist sent the following account of his discovery:

"When a nail or a piece of thick brass wire, etc., is put into a small apothecary phial and electrified, remarkable effects follow, but the phial must be very dry or warm. If a little mercury or a few drops of spirits of wine be put into it the experiment succeeds the better. As soon as this phial and nail are removed from the electrified glass, or the prime container to which it has been exposed is taken away, it throws out a pencil of flame so long, that, with this burning machine in my hand, I have taken above 60 steps, in walking about my room. When it is electrified strongly I can take it into another room and there fire spirits of wine with it. If, while it is electrifying, I put my finger, or a piece of gold, which I hold in my hand, to the nail, I receive a shock which stuns my arms and shoulders. When I place this phial and nail to a tin tube which I have, 15 feet long, nothing but experience can make a person believe how strongly it is electrified. It appears to me extraordinary, that when this phial and nail are in contact with either conducting or non-conducting matter the strong shock does not follow. I have cemented it to wood, metal, glass, ceiling wax, etc., which I have electrified without any great effect. The human body, therefore, must contribute something to it. This opinion is confirmed by my observations, that, unless I hold the phial in my hand I can not fire spirits of wine with it."

A year later Cuneaus and P. van Mussenbroek (1692–1761), professors at the University of Leyden, built a similar jar at the University of Leyden. The description of the first experiments of the two Dutch physicists with their arrangement designed to collect and store static electricity is of great interest:

"A gun-barrel was suspended on silken strings, having one of its ends very near a glass globe, which was turned rapidly, while electricity was excited in it by friction with the hands. A wire was hung from the other extremity of the gun barrel, which dipped into a beer glass full of water, and held in the hands of one of the other gentlemen. After the globe had been driven for some time, the gentleman who held the beer glass approached his finger to the gun-barrel to draw a spark from it. The consequence was a shock, differing in violence according to the length of time that the globe had been turned."

Immediately after the discovery of the "Kleist" or "Leyden" jar, the attention of the whole world was directed to the wonderful and mysterious actions of these jars. Within a short time the experiments with Leyden jars were publicly exhibited for money in all the principal cities of Europe. Exaggerated reports about their curative actions were circulated. It is to Franklin's credit that he soon explained the actions of the Leyden jar on the basis of his own theories on electricity mentioned before. He says in one of his letters to Collinson:

"At the same time that the wire and top of the bottle etc. is electrified positively or plus, the bottom of the bottle is electrified negatively or minus, in exact proportion, i.e. whatever quantity of electrical fire is thrown in at top, an equal quantity goes out of the bottom. So

wonderful are these two states of Electricity, the plus and minus, combined and balanced in this miraculous bottle situated and related to each other in a manner that I can by no means comprehend! If it were possible that a bottle

A N

ACCOUNT

OF THE

EXPERIMENTS

MADE BY

SOME GENTLEMEN of the ROYAL SOCIETY,

In order to discover whether the ELECTRICAL POWER would be sensible at great Distances.

WITH

An Experimental Inquiry concerning the respective Velocities of ELECTRICITY and SOUND.

To which are added,

Some further Inquiries into the *Nature* and *Properties* of ELECTRICITY;

Communicated to the ROYAL SOCIETY,

By WILLIAM WATSON, *F. R. S.*

LONDON:

Printed for C. DAVIS, over-against. *Gray's-Inn Gate, Holborn.* 1748.

[Price One Shilling and Six-pence.]

FIG. 17. Title page of Watson's book on electricity.

should in one part contain a quantity of air strongly comprest, and in another part a perfect vacuum, we know the equilibrium would be instantly restored within. But here we have a bottle containing at the same time a plenum of electrical fire, and a vacuum of the same fire; and yet the equilibrium can not be restored between them but by a communication without! though the plenum presses violently to expand, and the hungry vacuum seems to attract as violently in order to be filled."

On the other hand, Abbé Nollet who coined the name "Leyden jar" added it to his sensational demonstrations in public. In the presence of the King, he killed small birds and animals by a discharge of the jar. He discharged a jar through 180 soldiers of the Royal Guard and also through the monks of the Parisian Convent of Carthusians who stood in a row 180 meters long and the whole company, upon the discharge of the phial, gave a sudden spring at the same instant of time and all felt the shock equally. Naturally the idea of using this newly found agent to cure certain diseases occurred to many experimenters. The effects were tried on paralytics, but without success. While the original Kleist jars were filled with water which acted as one electrode, they later were lined inside and covered with tinfoil, which was a suggestion made by the Englishman, Watson. Franklin explained again that the two tinfoil plates of the bottle contained electric charges of opposite polarity because the inside plate usually receives more than the ordinary amount of electricity and is, therefore, positively charged, while the ordinary amount of electricity on the outside cover is reduced and is a negative charge, but if the surplus of the positive charge of the inner plate is brought to the outer plate by a conductor, a spark occurs which is followed by a report.

Franklin's scientific experiments were conducted as a hobby. Both his scientific and governmental successes brought him honors, not only in his own country, but also abroad. His scientific contributions became of great significance in the development of electricity and were published in many collections, the most important of which are "Experiments and Observations on Electricity made at Philadelphia, 1751–1754, (London 1769)," and also his "Letters on Electricity." The first of these publications consists of several letters which Franklin wrote between July, 1747 and April, 1754, to Peter Collinson, a fellow of the Royal Society in London. How great the impression of these letters was can be seen from Priestley's words: "Nothing was ever written upon the subject of electricity which was more generally read,

and admired in all parts of Europe than these letters. It is not easy to say, whether we are most pleased with the simplicity and perspicuity with which these letters are written, the modesty with which the author proposes every hypothesis of his own, or the noble frankness with which he relates his mistakes, when they were corrected by subsequent experiments." Aside from all of his serious scientific work, Franklin was thoroughly human. The story of his electric dinner is still told today. "A turkey was killed by electricity, roasted on an electric fire, and the health of all famous electricians in England, Holland, France and Germany was drunk out of electrified glasses under the thunder of discharges of an electric battery."

Franklin died from a lung abscess on February 17, 1790. He wrote his own epitaph. It reads:

"The Body
of
Benjamin Franklin, Printer
(Like the cover of an old book,
Its contents torn out,
And stript of its letters and gilding),
Lies here, food for worms;
Yet the work itself shall not be lost,
For it will (as he believes) appear once more
In a new and more beautiful edition,
Corrected and amended
by
The Author"

The work of Franklin made its impression upon contemporary scientists in the old and new worlds. First among these may be mentioned Sir William Watson (1715–1787), an Englishman, whom Priestley called "the most interested and active person in the kingdom in everything relating to electricity." Watson had heard of Franklin's idea of the lightning rod and introduced it in Europe in 1762. Long before this time, however, Watson worked extensively with Leyden jars. His first letters were communicated to the Royal Society in March and October, 1745. He tried to determine the longest distance through which the discharge from a Leyden jar could be transmitted through wires, and in July, 1747, made his famous experiment "to convey the electric shock across the river Thames, making use of the water of the river for one part of the chain of communication" (Fig. 17). In 1753 he constructed a glass tube three feet long which was evacuated by means of a Smeaton pump and through which he sent high

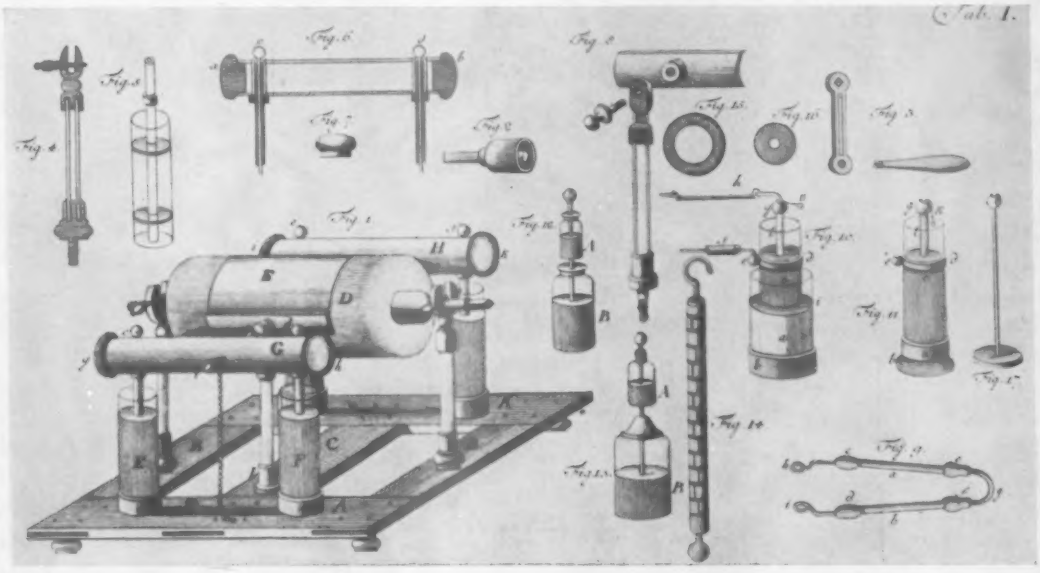

Fig. 18. One of Bohnenberger's "Electrisier-Maschinen."

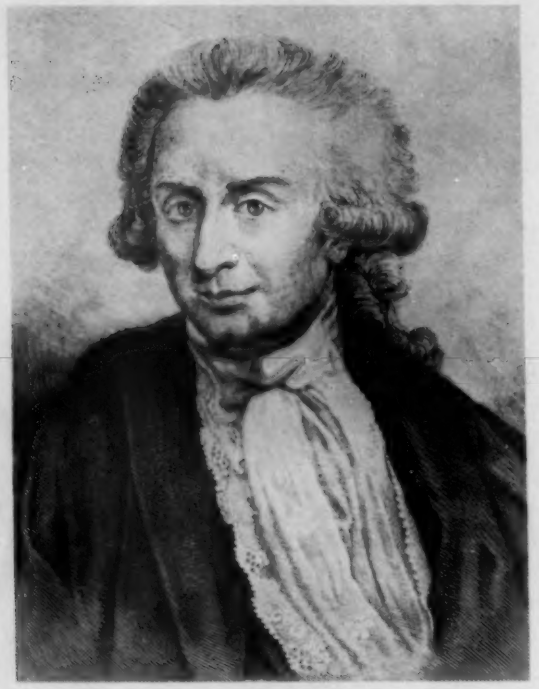

Fig. 19. Luigi Galvani (1737–1798).

Fig. 19*a*. Alessandro Volta (1745–1827).

tension currents. His demonstrations of the manifold electrical and optical phenomena which were created by the discharges made a great sensation. Watson's experiments on conducting electrical shocks over long distances also brought him great admiration. Mussenbroek, one of the discoverers of the Leyden jar, wrote him on one occasion, "Magnificentissimis tuis experimentis superasti conatus omnium."

Another predecessor of Roentgen's was also an Englishman, William Morgan (died 1785), who perhaps was the first one actually to produce the x-rays. Morgan, in a lecture before the Royal Society in February, 1785, reported on his repetition of Torricelli's vacuum experiments. In performing these experiments he followed the advice of du Fay and cleaned the mercury in his barometer tube very carefully. In this way he was able to obtain a vacuum which was so high that he did not succeed in obtaining a discharge of the high tension through the tube. In one experiment a tube cracked and when the air slowly entered it, Morgan observed a beautiful display of colors which changed continuously. This gave him the idea that it might be possible to estimate the vacuum in the tube by the various color changes. Morgan most probably produced roentgen rays in these experiments and his suggestion of studying the color range in a discharge tube in order to obtain an idea of the degree of vacuum was destined to become important in later years when vacuum tubes were more highly developed.

It is impossible to mention all the scientists who subsequently contributed to the knowledge of electricity or of the vacuum and to the improvement in apparatus. The German professors, C. A. Hansen of Leipsic (1693–1743), G. M. Bose of Wittenberg (1710–1761), F. H. Winckler of Leipsic (1703–1770), and the Scotch Benedictine monk, P. Gordon (1712–1751), made many improvements in electrostatic machines and vacuum pumps, notably the substitution of the globe for the tube used since Hauksbee's time, the introduction of

mechanical rotation using a heavy wheel and a pedal arrangement, insulated conductors, substitution of the hand by a rubbing cushion with springs to excite the globe, the use of one and later of four cylinders. In 1746, B. Wilson (1712–1788), introduced the comb collector for the static apparatus. Further improvements were made by Bennet, Erasmus Darwin and G. C. Bohnenberger. It was especially Bohnenberger, a minister in a small German village, who was a most prolific worker with "Elektrisier-Maschinen." He wrote six extensive treatises on the history of these machines and notably on his own constructions (1784–1791) (Fig. 18).

But going back to Franklin's time we find that the many attempts to measure the amount of electricity by means of some type of electroscope as conceived by du Fay and Nollet were continued by two other Frenchmen, le Roi and Chevalier d'Arcy, who probably were the first to measure electricity quantitatively by means of an ingeniously constructed electrometer. John Canton (1718–1772) "an eminent electrician" in England also took up Nollet's idea and he used two small spheres of elderberry pith which were suspended on fine silk strings in a box so that when charged the two spheres repelled each other and the amount of separation could be taken as a measure of the electric charge. Canton was a successful experimenter and he made excellent observations on phenomena of electrostatic influence. His friction experiment made in 1753 with a glass rod which was polished on one side and roughened on the other is of fundamental significance. When this glass rod was rubbed with a piece of hard rubber, two different kinds of electricity were produced for the first time on one material, positive electricity on the polished surface, and negative on the roughened surface. Canton also made the suggestion that cushions of electric machines be covered with mercury-tin amalgam in order to increase their efficiency. Two other contemporaries of Canton belong to this group of scientists, J. K. Wilcke (1732–1796), a Swede, who lived in Germany, and Beccaria of Italy. Both experimented with the phenomena of electrostatic influence similar to those investigated by Canton and they were able to solve many problems about which there was considerable uncertainty.

Thus far the electrical phenomena observed came from frictional electricity or from atmospheric electricity. The eighteenth century brought the knowledge of a new kind of electricity. Among its discoverers were notably two Italians, Luigi Galvani (1737–1798) (Fig. 19), and Alessandro Volta (1745–1827) (Fig. 19*a*) who distinguished themselves by important discoveries, and the Frenchman, Coulomb. Luigi Aloisius Galvani, born on September 9, 1737, at Bologna, originally prepared himself for a theological career but later acceded to the wishes of his parents and studied medicine. In 1762 he was appointed Lecturer in Anatomy and in 1775 Professor of Anatomy at the University of Bologna. His observations on the twitching of a frog's leg suspended by a copper hook to an iron rail, and the conclusions which he based upon this experiment are familiar to everyone. Galvani was of the opinion that the effects were due to the metallic connection between the outside negative electricity in the muscle and the inner positive electricity of the nerves. His first publication on these observations which he called "Animal Electricity" appeared in 1786 but he continued his experiments and five years later he published his famous thesis "De Viribus Electricitatis in moto musculari commentarius," which appeared in the Memoirs of the Institute of Science in Bologna in 1791, and a year later also in Modena. Most of his important experiments were made in November and December, 1780, and all through the year 1781. Galvani died on December 4, 1798, during his sixty-first year, in the house of his brother, Giacomo, at Bologna. He was heartbroken because the government of the Cisalpine Republic in April, 1798, had stripped him of all his offices and honors

since he would not render the oath of allegiance to the new government. Finally the government at the recommendation of Professor Aldini reinstated him at the University, but the great scientist was dead before the news reached him.

It was Galvani's great fortune to discover a new kind of electricity, though he himself erroneously thought that the tissue itself was the source. In his writings he expressed the hope that his observations would be studied further by prominent scientists of his time. This desire was soon fulfilled by Volta, his famous contemporary, who repeated a number of Galvani's experiments and penetrated still more deeply into the secret of the newly discovered source of electricity.

Alessandro Guiseppe Antonio Anastasio Volta, who continued Galvani's experiments so successfully, was born on the 18th of February, 1745, at Como. He was made Professor of Physics at the Gymnasium of Como at the age of twenty-nine. Five years later he was offered the newly founded chair of Physics at the University of Pavia. Volta came in contact with many contemporary scientists, Davy, Arago, Lichtenberg, Lavoisier, Laplace, Priestley, and others, on his numerous journeys through Europe, and learned many new and important facts in his discussions with them. In contrast to his countryman, Galvani, he was on good terms with Napoleon Bonaparte who later invited him to Paris in 1801 to give a demonstration of his experiments on contact electricity and on his newly invented Volta pile. Many honors were heaped upon him there including a special gold coin struck with his image upon it.

(*To be continued in September Issue*)

MULTIPLE MYELOMA WITH SPINAL CORD INVOLVEMENT*

By HAROLD W. JACOX, M.D., *and* EDGAR A. KAHN, M.D.
ANN ARBOR, MICHIGAN

THERE is seldom an opportunity to study the complete disappearance of a vertebra. One case we are reporting clearly demonstrates this phenomenon. Another unusual feature is the excellent palliative result obtained while observing the patient over a period of five years. This would have been considered a solitary myeloma had not sufficient time elapsed wherein multiple lesions could be demonstrated.

REPORT OF CASES

CASE 1. M.M., a mechanic, aged thirty-one, entered the University Hospital February 10, 1928, with a chief complaint of pain in the back. This had first been noted in the mid-lumbar region two years before. A kyphosis was noticed by the patient's wife eight months before entrance.

In November, 1927, the patient had been referred by his physician to Dr. S. E. Sanderson of Detroit for roentgen studies. These revealed a destructive lesion of the third lumbar vertebra, and a diagnosis of myeloma was made.

The pain gradually increased in severity and an area was noted on the right thigh which felt cold and at times as if the "skin were raw." One month before entrance, putting any weight on the spine was unbearable and he supported himself in the sitting position with his hands. The wife stated that at times the pain was so excruciating he became delirious.

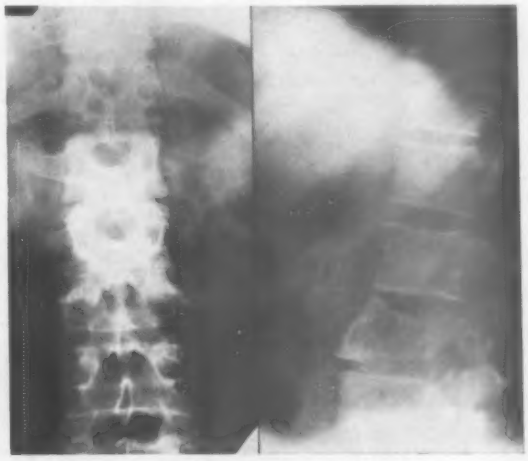

FIG. 1. November 25, 1927. Original films demonstrating destruction of third lumbar vertebra. (Courtesy of Dr. S. E. Sanderson.)

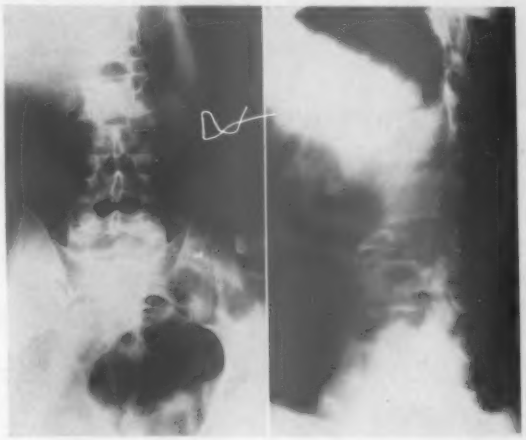

FIG. 2. February 11, 1928. Preoperative roentgenogram showing additional destruction.

The past history was essentially negative. There was no history of operations or injuries. No nocturia, dysuria or incontinence. Little was known of the family history.

Examination revealed a well-nourished young adult male lying on his side with the knees drawn up apparently suffering great pain. There was a well-rounded kyphosis in the lumbar region.

The pupils were equal and regular, reacted to light and in accommodation. The thyroid gland was not palpable and there was no cervical adenitis. On chest examination there were no areas of dullness and no râles persisted after cough. The heart was not abnormal. The blood pressure was 128/80. There were no masses or areas of tenderness in the abdomen. The liver and spleen were not palpable.

Considerable wasting of both legs was pres-

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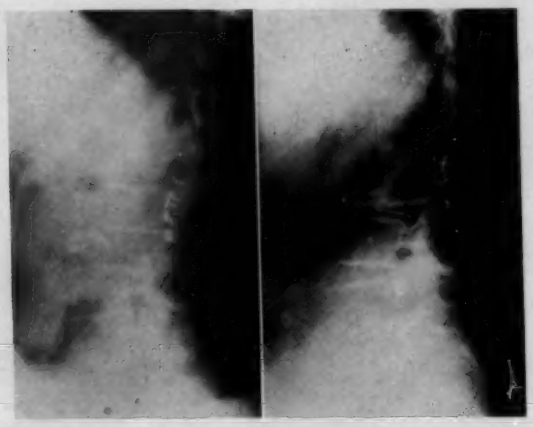

A B

Fig. 3. A. April 5, 1928. Metallic densities are silver clips used at operation to control hemorrhage. B. May 3, 1930. Destruction continues.

ent. The knee and Achilles reflexes were active and equal. Babinski's sign was negative. The sense of motion and position of the toes was normal. There was an area of hypalgesia on the anterior aspect of the right thigh quite well localized to the second and third lumbar segments.

The blood Kahn reaction was negative. Hemoglobin, 84 per cent; white blood cells, 7,200. The urine was negative. No Bence-Jones protein reaction.

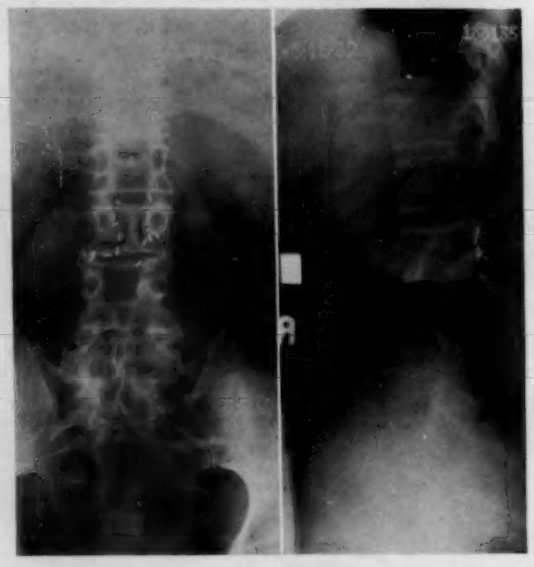

Fig. 4. August 16, 1932. Complete disappearance of third lumbar vertebra. Note second lumbar now rests on fourth.

Roentgen examination on February 14, 1928, revealed normal contour and alinement of the first two lumbar segments. The third lumbar segment was partially reduced in size and had

Fig. 5. August 16, 1932. Typical myeloma lesion in right humerus.

lost a large amount of its calcium content. It lay anterior to the second segment and a portion of its lamina had been destroyed, although its arch was preserved. The body of the fourth lumbar vertebra also lay anterior to a line drawn through the anterior portion of the first and second segments. Studies of the skull,

pelvis, ribs, lungs, right femur and tibia were entirely negative (P. M. Hickey).

Because of the severity of the pain and the area of diminished sensation, it was felt that nerve root involvement was present. Laminectomy was advised.

On February 15, 1928, under nitrous oxide ether vapor anesthesia, a midline incision was made by Dr. Max Peet with removal of the posterior spinous processes and laminae of the second, third and fourth lumbar vertebrae. Opposite the third lumbar the dura was much flattened and about twice its normal width from pressure of tumor anterior to the dura. This tumor passed laterally on the right so that it encircled the third lumbar nerve immediately after its exit from the dura. The veins anterior to the dura were enormously dilated and bled freely. The hemorrhage was controlled with silver clips and muscle grafts. The tumor around the third nerve and a portion of the tumor within the bed of the third lumbar was removed with a curette. The nerve roots of the third lumbar segment were pressed upon by the tumor at their entrance into the bony canals. The dura was opened, and the posterior roots of the second and third segments divided. The proximal and distal ends were caught with silver clips as the veins accompanying them were larger than normal. The dura was closed with a continuous silk suture. The muscles were closed in layers.

Postoperatively the patient's condition was poor and he was given 500 c.c. of 5 per cent glucose. He was placed upon a Bradford frame. The following day his condition was improved and he was turned by means of an anterior mould. A superficial pressure sore developed over the sacrum but healed rapidly. The patient was up in a wheel chair with a back brace, on March 18, 1928, and was walking about the ward in his back brace feeling perfectly well. The microscopic diagnosis was "typical plasma cell myeloma."

Three weeks after the operation the patient received a total roentgen dosage of 575 r (measured in air), quality 0.15 Ångström units, directly over the operative site with a field 10×15 cm. in four equally divided daily doses.

Subsequently he returned as an out-patient at intervals of a month to six weeks and received one-fourth of the above total dose with the same technique for a total of twenty-five treatments. This consisted of 3,375 r over approximately a four-year period, the last treatment being given in December, 1931. Check-up roentgenograms showed progressive disappearance of the third lumbar vertebra.

There was no further trouble until July, 1932, the patient having worked continuously as a mechanic and clerk. The brace was always worn except at night. In July, 1932, the backache again commenced. The patient felt as if his "back was tired." In August, when walking, a sharp pain came on without warning. He supported himself to take the weight off the spine and was somewhat relieved although breathing was painful. He stayed in bed one week without pain and gradually got up. He noticed that he was free from pain at first but after being up several hours it was necessary to return to bed.

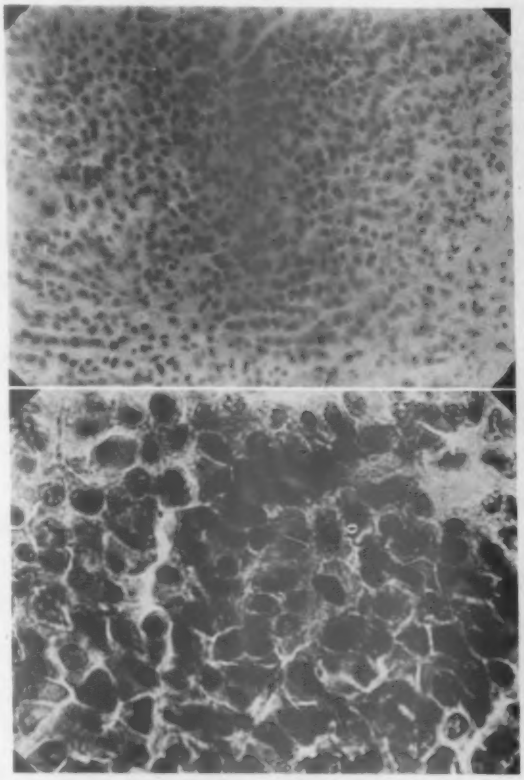

Fig. 6. Photomicrograph of plasma cell type of myeloma.

Roentgen examination of the spine now revealed involvement of the second and fourth lumbar vertebrae. The skull, ribs, right humerus and femur had the typical appearance of punched-out lesions of multiple myeloma.

The Bence-Jones reaction was positive. Blood smears revealed no gross abnormality. The hemoglobin was 80 per cent; red blood cells, 4,420,000, and white blood cells, 12,350.

Neurological examination by Dr. Waggoner revealed that the right knee and Achilles reflexes were normal. The left knee and Achilles reflexes were not obtained. Vibratory sense and sense of motion and position of the toes were normal. Sensation was almost completely lost in the distribution of the first, second and third lumbar segments, with slight diminution in the fourth and fifth lumbar; apparently none in the first sacral segment.

This diminution of sensation was certainly more extensive than could be accounted for by previous posterior root section so that further involvement of the cauda equina had developed.

On September 16, 1932, medium wave length roentgen therapy was recommended, using a cross-fire method to each side of the lumbar spine. After five treatments at weekly intervals the patient obtained complete relief of pain. Treatments were not given over the other skeletal lesions because of their multiplicity and freedom from pain. In July, 1933, he reported himself as symptom-free.

Case II. C.M., a farmer, aged sixty, entered the University Hospital March 13, 1933, with a chief complaint of paralysis of both legs. The first symptom had come on six weeks before with a numbness of the feet which gradually spread to the nipple line. Pain had been noted shooting across both sides of the upper abdomen. There were no bladder symptoms.

On examination there was some voluntary movement of the left ankle, none of the right. The knee jerks were hyperactive. Plantar irritation gave a positive Babinski's sign on the right with no movement of the toes on the left. There was an almost complete sensory paralysis to the sixth dorsal segment. A complete subarachnoid block was demonstrated.

The urine was essentially negative, and there was no Bence-Jones reaction. Hemoglobin, 80 per cent; red blood cells, 4,670,000; white blood cells, 5,600.

Roentgen examination revealed a destructive lesion of the fourth dorsal vertebra. There was a small area of rarefaction in the right femur. The general physical examination gave no evidence of a primary malignancy and it was felt that the lesion was a myeloma.

Under local anesthesia, a laminectomy was performed (Dr. E. A. Kahn). Three laminae

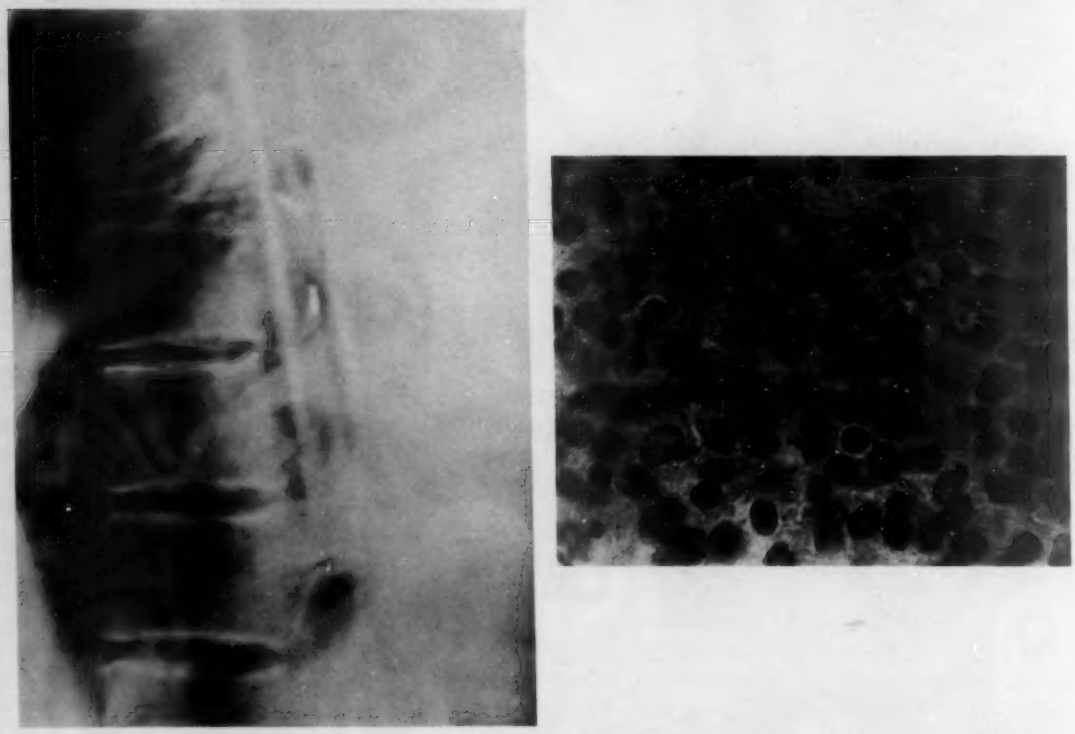

Fig. 7. Postoperative roentgenogram and photomicrograph of Case II.

were removed centering over the fourth dorsal vertebra. It was seen that the dura was pushed posteriorly by a grayish-black, rounded mass arising from the body of the fourth dorsal vertebra. The posterior spinal ligament was incised over the tumor and a small amount removed. The same afternoon the patient was moving both legs. In spite of a severe attack of facial erysipelas the patient was up walking in a Taylor back brace six weeks postoperatively. The microscopic report was "myeloma, probably myeloblastic in type."

One month after operation the patient received the following roentgen dosage: 650 r (measured in air), effective wave length 0.15 Ångström units, cross-firing the laminectomy site obliquely through each of two portals (one per day), 10×15 cm. in size.

The patient reported in July, 1933, that he was working daily and was free from pain.

We have found 3 other cases in the literature with spinal involvement subjected to laminectomy.

Case I. A case is described by Wakeley[3] of a man, aged forty-one, seen in September, 1927, complaining of "loss of power and sensation" in the legs. Laminectomy was performed by Sargent in January, 1928, extradural, soft vascular tissue being removed. The microscopic report was "plasma celled myeloma with fairly large cells."

The patient was symptom-free until October, 1929, when the symptoms recurred. He was given a course of roentgen therapy with improvement, though some weakness remained in the left foot. The outcome is not given in this case though he was still alive and about, November, 1931.

Case II. Coley[2] reports the case of a man, aged fifty-six, who in 1922 complained of pain in the lumbar region and later severe abdominal pain shooting down the legs. He received high voltage roentgen therapy with considerable relief of pain. A year later there was an increase in pain with rapid development of paralysis. He was operated upon by De Martel of Paris, a semi-cylindrical tumor being found which nearly encircled the cord. It was removed as thoroughly as possible and roentgen therapy given postoperatively. The paralysis and pain disappeared, though the patient never regained control of the bladder. Coley's toxins were used after multiple lesions had been demonstrated in the ribs, spine and chest. A year later there was no roentgen evidence of involvement of the skeletal bones.

There was in this case some disagreement as to the microscopic diagnosis though Coley reports it as myeloma. The patient was still alive and active in 1931.

Case III. Cabot[1] reports the case of a laminectomy performed by Mixter for myeloma at the fourth dorsal vertebra. The patient was in extremely poor condition before operation with a respiratory paralysis necessitating the use of the Drinker respirator for a time. A complete motor and sensory paralysis extended to the sixth dorsal segment. A hemorrhagic cystitis was also present. The patient lived only fourteen days postoperatively so that the ultimate operative result could not be determined.

CONCLUSIONS

These cases clearly show the palliation obtained by laminectomy plus roentgen therapy in what is ordinarily considered a hopeless condition. With severe cord compression, laminectomy should always be performed before the therapy is given. This permits the establishment of a positive diagnosis and prevents further damage to the cord by swelling subsequent to irradiation.

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ABSENCE OF LEFT DIAPHRAGM ASSOCIATED WITH INVERTED THORACIC STOMACH

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THE presence of abdominal organs within the thorax, while not a common occurrence, is no longer considered a rarity. The following conditions are recognized:

1. Diaphragmatic hernia. Only a few cases reported until the end of the Nineteenth Century, but not an infrequent finding since the diagnostic use of roentgen rays has become universal. A review of all the cases in the literature would constitute quite a formidable task and would probably not include all the actual cases as many at present are not reported. The abdominal organs enter the chest cavity through a rent or defect in the diaphragm or through one of the regular openings which happens to be abnormally large. The organs are at times seen above the diaphragm, at other times they may be found within the abdomen, below the diaphragm. The latter fact accounts for the great discrepancy in incidence reported by various authors, as many hernias probably remain unrecognized if small or if not looked for.

2. Eventration of the diaphragm. The abdominal organs are not really in the chest cavity proper, but only appear to be in the thorax. The diaphragm is at all times above the abdominal viscera, being stretched and pushed up into the chest.

3. Thoracic stomach with short or long esophagus. In contradistinction to the other conditions mentioned, the esophagus does not go through the diaphragm. Either the duodenum or the pyloric portion of the stomach passes through the esophageal opening in the diaphragm. The stomach *at all times* is found in the chest cavity proper. Only 8 cases are so far reported in the literature.

4. Absence of left diaphragm. This was considered by some as almost incompatible with life[12] but 12 cases to date have been reported in the literature, several in patients of advanced age.

Ordinarily, the differentiation between these anomalies is very simple. A very lucid description of the various conditions is given by LeWald.[19,20] However, in practice it is not always easy to classify the cases correctly and errors of diagnosis are not infrequent. Eventration and hernia are most commonly confused and thoracic stomach is sometimes described as hernia. LeWald calls attention to just such an error. The left diaphragm is sometimes difficult or impossible to demonstrate roentgenologically so that one cannot be absolutely certain whether he is dealing with a thoracic stomach of the long esophagus type, with a large hernia or with a case of an absent left diaphragm. The case cited below presents such a difficulty. The most serious error, however, pointed out by many authors is that of mistaking the presence of the stomach in the chest for hydropneumothorax, as also happened in this case. Fortunately for my patient, the attempts at paracentesis were unsuccessful. Several extraordinary features in this case, besides its rarity, make it worthy of detailed report and discussion.

REPORT OF CASE

H. F., male, aged thirty-nine, born in Crimea, Russia, has always enjoyed good health. Upon careful questioning, however, it was brought out that, while he had no difficulty in playing all kinds of games with the boys, he could never keep up with them in climbing mountains or in any other particularly strenuous physical exercises. He nevertheless participated in all athletic sports without ill effects. His appetite and bowel action have always been normal. In 1914 he was drafted into the Russian army and was sent to the front.

* Read before the New York Academy of Medicine, March 15, 1932.

In January, 1915, while shooting in lying position on his abdomen on level ground, he was wounded in the lower back by a piece of shrapnel. He did not become unconscious, although he lost considerable blood and remained on the battlefield unattended for eight hours before the Austrians picked him up. He was in a hospital for several months until the wound healed. There was no paralysis or difficulty with the function of bladder or rectum. During his hospital stay, he was examined under the roentgenoscope to determine whether any piece of shrapnel was remaining in his back, but none was found. He observed, however, that the doctors in roentgenoscoping him showed great surprise and displayed unusual interest, demonstrating him to others on the staff. He could not understand their conversations, but knows that there was no fracture or other injury to the skeletal system found. After discharge from the hospital, he remained a war prisoner for three years and escaped back to Russia in 1918.

His life from 1914 on has been a very strenuous one. The Russian army at the front suffered a great deal from the cold winter, being poorly clothed and lacking shoes. The Austrians, according to his statement, fed the war prisoners badly and the camp hygiene was also bad. Upon return to Russia he was confined in prison as a political suspect for a long period of time, escaped to Constantinople where he lived for over a year, and in 1922, he immigrated to America. In spite of all the hardships, he was always in perfect physical condition.

Fig. 1. Real hydropneumothorax. Note: heart not displaced, collapsed lung compressed against mediastinum, no lung tissue visible through gas.

Fig. 2. False hydropneumothorax. Note: heart displaced to right, lung not collapsed, but surrounds gas-filled area, which occupies a central position. Some lung tissue can be seen through the gas. Stomach full.

In September, 1925, after a heavy meal, he suddenly developed an attack of marked oppression in the chest and was only relieved after a hypodermic injection of a narcotic and after copious vomiting. A similar attack occurred in April, 1926; it was associated with nausea, severe pain in the back, profuse perspiration and headache. Physical examination disclosed distant breath sounds in the left apex with few râles. There were elicited all the classical signs of hydropneumothorax of the left chest. The heart sounds were indistinct, the apex of the heart being diffuse and to the right of the sternum. He was again relieved after administration of a narcotic and after vomiting. A medical consultant was called in and he also found signs of fluid and gas in the left chest and confirmed the diagnosis of hydro-

Fig. 3. Same as Figure 2 on fasting stomach. Note: no fluid level, large gas bubble.

pneumothorax. The question of etiology was not clear, whether it was due to pulmonary tuberculosis or was the result of the injury received in the war. He was referred to one of the best hospitals in New York for observation and treatment. I am indebted to Dr. I. Astrachan for the description of the first two attacks. The following is the communication the hospital sent me in answer to my inquiry:

"Date of admission to hospital—April 29, 1926.

Date of discharge from hospital—May 11, 1926.

Diagnosis: Hydropneumothorax; pulmonary tuberculosis.

Last known condition: Improved.

Roentgen Report, April 30, 1926:—Examination of the chest shows a collection of fluid in the left chest extending up to the level of the 4th rib anteriorly. Above this there is a pneumothorax extending up to about the 2nd rib anteriorly. Surmounting this the collapsed lung is seen, which shows no definite abnormality except perhaps some fibrosis.

The heart and mediastinum are displaced to the right side.

Final note: Patient with a negative past history, who enters with complaint of sudden sharp pain in the chest one month before admission. On physical examination there is evidence of hydropneumothorax in the left chest which is confirmed on roentgen examination. Also some fibrosis seen at left apex. Sputum repeatedly negative for tubercle bacilli. Aspiration was repeatedly unsuccessful."

He left the hospital against advice, not wishing to submit to a third paracentesis thoracis as the first two were very painful.

The next attack occurred January 30, 1927, and was even more severe than the previous ones. His pulse was very weak and rapid, 130 per minute. He was relieved by vomiting of large quantities of recently ingested food and after an enema, and had to remain in bed for two days because of weakness.

The patient was referred to me for observation on March 22, 1927, by Dr. D. L. Elkind. He complained of no digestive disturbances except for excessive belching and some abdominal discomfort. His bowel action has always been regular. No dietary restrictions except for avoidance of red meats. Never used tobacco or alcoholics. Weight fairly stationary. No previous serious illness.

Physical examination was essentially negative, except for the chest findings. He looked

Fig. 4. Same as Figure 3 after introduction of stomach tube and aspiration of fasting contents. Note diminution of gas bubble and expansion of lung.

well-nourished, weighing 193 lb. Height 5′ 11″. Had good color but seemed to be somewhat short of breath. Configuration of chest symmetrical, rather round. The apex of the heart located one inch within the right nipple line and is diffuse. Percussion of the right side of the chest discloses an area of relative dullness extending to the right nipple, corresponding to the displaced heart. The percussion of the left side of the chest shows tympany in the upper half anteriorly as high as the clavicle. At other times it extends only to the 4th rib. There is dullness over the left lower chest.

Roentgenoscopic examination of the chest discloses a condition which very closely simulates hydropneumothorax. However, there is no evidence of compression of the left lung. On respiration there is paradoxical movement of the upper level of the gas-filled area noted. On close examination one can see some lung tissue through the gas. Re-examination after the aspiration of the stomach reveals a marked change in the picture. The gas area is considerably lower, the fluid having disappeared and the lung in the left chest becomes more prominent. This occurs only when the stomach is emptied by means of a tube, but the fasting stomach shows a very large gas bubble. The left diaphragm cannot be seen and the left base is quite dense (Figs. 1, 2, 3, 4 and 5). The condition is apparently one of thoracic stomach of the long esophagus type. Upon administration of an opaque meal, the stomach is seen to be filling in a water-trap fashion, is completely inverted, the cardia being just above the level of the diaphragm, the lower pole occupying the highest position in the chest. The pylorus and first portion of the duodenum lie mesial and behind the cardia, crossing it on entering the abdominal cavity (Figs. 6, 7 and 8). Further study reveals that part of the colon is also in the thoracic cavity. It required two large films to take a roentgenogram of a barium enema, as the colon extends from the right iliac fossa to the left clavicle (Figs. 9 and 10). There was no disturbance in motility of the stomach or intestine noted. The left diaphragm could at no time be definitely visualized and is either entirely absent or deficient to such an extent as not to be demonstrable.

Fig. 5. Lateral view. Fasting stomach. Only right diaphragm can be made out.

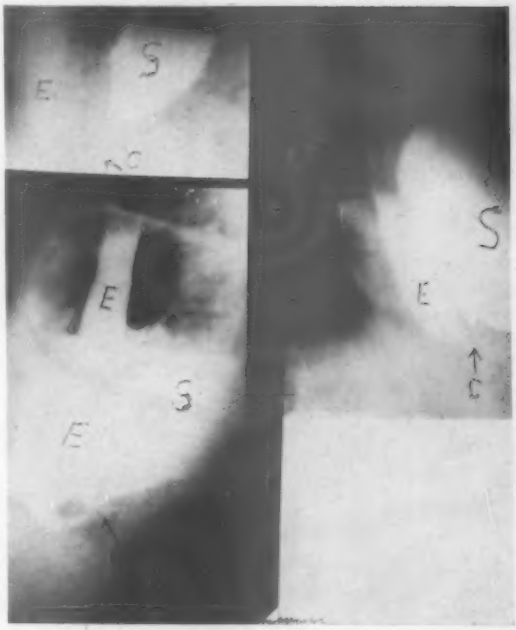

Fig. 6. Stomach in various stages of filling. Note water-trap appearance of esophagus with fluid level about the same as in the stomach.

The patient had no trouble until January, 1929, when another severe attack occurred. He was readily relieved after evacuation of the stomach was accomplished by change of pos-

Fig. 7. Stomach full. Oblique view. Duodenal bulb above cardia. Stomach completely inverted.

ture. Last attack occurred in August, 1931, and also required medical attention.

The patient always found it necessary to sleep on his left side and he awakes whenever he happens to turn on his right side. During the attacks he feels worse in the sitting position.

Fig. 8. Stomach full. Posteroanterior position.

COMMENT

There is nothing in the history of the case to suggest that the condition is due to trauma as was first supposed. The only severe injury sustained (shrapnel wound) was when the patient lay flat on his abdomen and was hit from above. It takes a great deal of force to rupture the diaphragm and it usually occurs when a severe blow is dealt on the abdomen or when the abdomen is strongly compressed, neither of these conditions having occurred. In this instance there were no symptoms at the time indicating respiratory or circulatory embarrassment, as would be the case with sudden extensive herniation of the abdominal viscera into the thorax. On the other hand, the patient definitely states that from childhood he was unable to climb mountains or engage in other

Fig. 9. Five hours p.c. Small residue in stomach. Splenic flexure of colon above and lateral to stomach. Cecum in right iliac fossa.

activities which would call for prolonged strenuous effort. He had no difficulty, however, in his adult life and stood the vicissitudes of the army regimen and imprisonment without any trouble. The service at the front, in the Carpathian mountains, called for considerable effort, as the soldiers were poorly fed and clothed, wore torn shoes when the snow was deep and suffered from cold and exposure. It has not affected his health in the least and he does not recall any illness whatever. We are evidently dealing with an anomalous condition to which he has gradually become adapted. The circulatory and pulmonary reserve which was apparently limited in childhood gradually increased and became quite adequate as he reached adult age. We must conclude, therefore, that we are dealing with a congenital condition.

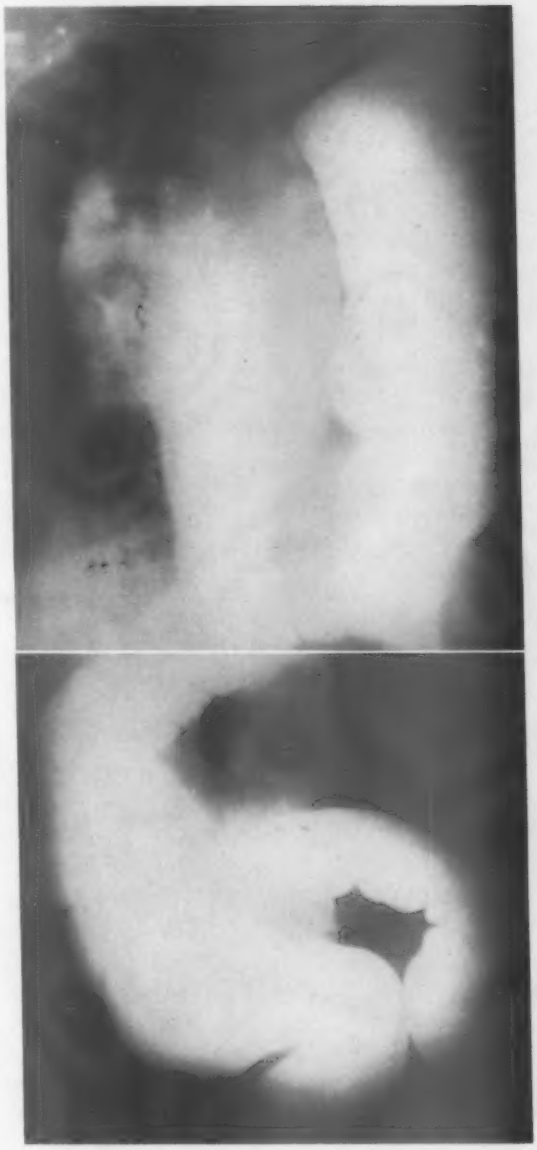

Fig. 10. Barium enema. Splenic flexure almost reaches the level of the clavicle.

NATURE OF THE ATTACKS

Judging from the description supplied by the patient and the attending physician, the attacks were probably caused by acute recurring volvulus of the stomach which untwisted itself under the relaxing influence of a narcotic or by change in the position of the patient. One can readily visualize how the stomach, in its inverted position when overloaded, may sag and, by its own weight, close off both the cardiac and pyloric orifices, producing real torsion of the organ. Most of the cases of volvulus or torsion of the stomach have been reported by surgeons, often as an accidental finding in operating for acute abdomen with no definite diagnosis.[1,2,8,14,22,27] Before the era of roentgenography, few cases were diagnosed preoperatively and some only on the autopsy table. However, not all cases come to surgery as recurrent volvulus with spontaneous reduction, though very rare, has been reported in the literature.[6,15,30] Payer[22] could find only 22 cases of volvulus of the stomach reported in the literature from 1866, when the first case was described by Berti, until 1909. Kocher and Richter[14] in 1914 reported 28 cases. For a complete bibliography and a thorough discussion of the subject, the reader is referred to the excellent article by Sutter,[27] who analyzed the 58 cases found in the literature up to 1929. Sutter, however, excluded all cases which were due to diaphragmatic hernia. In discussing the etiology of volvulus of the stomach, Payer, who frequently is quoted on this subject, mentions diaphragmatic hernia as one of the main predisposing causes. Another

factor responsible for the production of volvulus of the stomach, which may be considered in our case, is displacement by other abdominal organs (colon), particularly where the cardiac and pyloric ends of the stomach are made to approximate.

In the case reported here, the pylorus crosses the cardiac end of the stomach and one can readily conceive how an overfilled stomach in sagging may close off both orifices. It is worthy of mention that the patient, being aware of his condition, now tries to shorten the attacks by changes in posture, at times with fairly good results. As the attacks occur at infrequent intervals (four attacks in six years) he has not had many opportunities at experimenting with himself in developing the proper technique. He was warned against overloading the stomach as a prophylactic measure and seems to be quite successful in avoiding serious trouble for long periods of time.

DIFFERENTIAL DIAGNOSIS

This is not the first case in which the presence of the stomach in the thorax was mistaken for hydropneumothorax. References to this common error in diagnosis will be found in many reports dealing with diaphragmatic hernia, eventration or thoracic stomach. Attempts at aspiration were not always unsuccessful. Truesdale[29] cites a case in which milk was aspirated from the chest by exploratory puncture. Carman and Fineman[4] quote Downes as asserting that there are cases on record of death resulting from paracentesis thoracis because of mistaken diagnosis. Sailer and Rhein[24] report two exploratory punctures in a case of eventration with negative results. Struppler's[26] case had nineteen exploratory punctures of the chest with negative results before the correct diagnosis was made. Lebon[18] reported two cases of false pneumothorax, one in a soldier who had the stomach punctured twice by paracentesis thoracis.

Probably, if the paracentesis in my case had been done after a meal, it would not have resulted in a dry tap. Another possibility is that the colon, in its position between the stomach and chest wall, prevented successful aspiration. Cunningham and Shaw,[5] reporting a case very similar to mine, speak of this very common mistake, which really should not be made, if sufficient thought and care are given in arriving at a diagnosis. Harris and Stivelman[9] at first mistook a case of eventration of the right side of the diaphragm for hydropneumothorax but after careful deliberation and roentgenographic study with the administration of a barium meal, arrived at the correct diagnosis. Harris and Clayton-Greene[10] changed their diagnosis of pneumothorax to diaphragmatic hernia on clinical evidence. Likewise, Stivelman,[25] doubting the correctness of the diagnosis of pneumothorax in a tuberculous patient, administered a barium meal and found the case to be one of eventration. The opaque meal and roentgenoscopy always settle the question and should never be omitted, although a careful analysis of the history and physical findings should make one doubtful whether the case is really one of hydropneumothorax. This is especially true in those instances where the general appearance and condition of the patient seem too good to suspect a hydropneumothorax, which is a rather serious pathologic intrathoracic complication.

The differentiation between thoracic stomach, absence of diaphragm, eventration and hernia is often difficult and at times impossible. The diaphragm in eventration is sometimes so thin that it cannot be distinguished from the fundus of the stomach except at its attachments. Nor can one always be certain that the left diaphragm is absent when it is not demonstrable roentgenologically. As a rule, the recognition of the various conditions is simple as the characteristic points are quite definite and clear-cut, but some cases present features favoring one diagnosis, other evidence pointing to another. Korns,[17] in a critical review of the literature and discussion of the cases reported, points out many errors in diagnosis, when eventration

is called hernia, and vice versa. Meyers[21] seems to be entirely confused on the terminology. He reports a case as hernia of the diaphragm in which he was unable to see the diaphragm and makes a final diagnosis of diaphragmatic eventration.

Thoracic stomach is not always reported as such. LeWald calls attention to the case of Fineman and Connor[7] which was reported as diaphragmatic hernia, while it really should be considered a thoracic stomach. Likewise, the cases of Bund,[3] Plenk,[23] Huffman,[11] and Tonndorf,[28] cited by Fineman and Connor, according to the description of the authors, should be considered as true cases of thoracic stomach, as in all of them practically the entire stomach, including the cardia, was above the diaphragm, yet they were reported as herniae. Koppenstein,[16] in a comparatively recent article, describes a case of thoracic stomach and names it so in English, but calls it a herniated stomach as the German equivalent. This probably accounts for the fact that Jenkinson,[13] in reporting his case of thoracic stomach, failed to include these cases among those he mentions as previously reported.

In the case described above, where the diaphragm could not be outlined even at the periphery, and where the lung tissue could be made out through the gas bubble, one has to consider it as one of absent left diaphragm, associated with a thoracic stomach, inasmuch as the cardia is above the level of the diaphragm. However, it is possible that the diaphragm is defective to such an extent as not to be demonstrable. With the entire stomach and a large portion of the colon in the chest cavity, the defect in the diaphragm, if there is one, must be enormous, constituting really a partial or complete absence of the diaphragm. The comparative freedom from symptoms up to the age of thirty-three, and then over a long period of time, also suggests the presence of a large opening in the diaphragm, or the absence of same altogether, allowing of free movements of the stomach and splenic flexure of the colon without strangulation. This is not incompatible with long life and even with freedom from symptoms. LeWald reported the case of a man, thirty-four years of age, with complete absence of left diaphragm, who has won athletic honors in long distance running contests, and of a woman, aged sixty-three, with no evidence of a diaphragm on the left side and the abdominal organs in direct contact with the pleura and pericardium. Jenkinson, besides his own, collected 11 more cases from literature. Incidentally, the case of Harris and Clayton-Greene was also at first mistaken for pneumothorax.

SUMMARY

1. A case is reported of inverted thoracic stomach of the long esophagus type with periodic attacks suggesting acute volvulus or torsion of the stomach and associated with partial or complete absence of the left diaphragm.

2. The differentiation between thoracic stomach, absence of, eventration and herniation of the diaphragm usually presents no difficulty, but at times the exact diagnosis is impossible or almost so. The administration of a barium meal and roentgenologic examination simplifies the problem.

3. Attention is called to the frequency with which the conditions are mistaken for hydropneumothorax in spite of repeated references in the literature to the possibility of such an error and comparative ease of differentiation by means of a barium meal. More general recourse to the roentgenologic visualization of the stomach and colon with administration of an opaque meal would obviate such errors, especially when paracentesis thoracis is contemplated.

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AUDITORY EFFECTS OF ROENTGEN RAYS IN DOGS*

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INTRODUCTION

AS A preliminary investigation of the effects of roentgen rays upon auditory acuity in dogs, two animals were exposed to a variety of doses over a period of months.

Investigation upon the biological effects of roentgen rays ranges from studies on the single cell to studies on a complete human system. Perhaps least is known in regard to their effects upon sensory processes. For example, numerous reports in the literature are concerned with the effects of roentgen rays upon deafness; but in no case, for clinical reasons, have the studies dealt with their effects upon normal hearing. Inasmuch as deafness results from different pathological conditions it is not surprising that the results reported are inconsistent. An additional handicap is the inadequacy of present methods of testing hearing, as compared with the more standardized and accurate visual tests.[1] The results, therefore, have been contradictory: some studies reported beneficial effects with the use of roentgen rays in the treatment of impaired hearing,[2] while others have reported negatively.[3]

But if clinical data are meager and inconclusive, experimental data are totally lacking. Desjardins[4] has summarized rather thoroughly the experimental studies concerned with the effects of radium and roentgen rays upon the eye and ear. The number of studies concerned with the eye far outnumber those relating to the ear—202 titles against 50 titles—and none of these studies is concerned with the effects of roentgen rays on hearing as such. For therapeutic as well as for theoretical significance, an experimental technique for just this type of investigation—the study of the sense modality *per se*—appears to be of some importance. From a psychological point of view, the "conditioned response" technique suggests itself immediately, both for complete control of experimental conditions and for accurate measurement of auditory acuity.

The dog is used as the experimental animal for several reasons: adaptability to the conditioned response technique, relative ease in training and testing, domesticity, and possession of an auditory mechanism similar to that of man.

TECHNIQUE AND APPARATUS

The animal undergoes a preliminary training of about three weeks, during which time it is "conditioned" to respond to a given tone. The dog has a fixed position in a rack, with the right fore paw resting upon a metal grill through which a mild electric shock is administered (Fig. 1). The tone, a 1000 cycle sound, is presented for a three second period and followed immediately by a mild shock through the grill, just strong enough to effect a reflexive withdrawal of the dog's paw. The animal in this way learns to lift his paw as soon as the sound begins, and is tested for about a half hour each day—the tone and shock being given for 25 trials. Both the shock and sound are electrically controlled, the sound being presented at irregular inter-

* Communication No. 2 from the Alpha Research Laboratory, Department of Psychology. Special aid from the American Otological Society is gratefully acknowledged.

[1] Richardson, J. J. X-Rays as an advance in the treatment of hearing. *J. M. Ass. Georgia*, 1924, *13*, 161–165. He states that the "best single test (of hearing) is the distance measure of the spoken and whispered voice . . . while difficult to standardize, yet (a) skilled otologist can control his voice to determine whether hearing of subject has materially improved." P. 162 ff.

[2] *Ibid.* He used a 4" spark gap and 8 ma., and reports that "It was soon found that radiation could be directed practically anywhere on the head . . . with betterment of hearing clinically." P. 164.

[3] Desjardins, A. U. Action of roentgen rays and radium on the eye and ear. Am. J. Roentgenol. & Rad. Therapy, 1931, *26*, 634; 787; 919.

[4] *Op. cit.* This is perhaps the best summary of clinical as well as experimental data.

vals to prevent temporal conditioning. The dog is observed throughout the entire test through a window which is so constructed as to prevent the animal seeing the experimenter or getting any "cues" from his movements.

By the end of three weeks the animal is usually thoroughly trained, and ready for threshold (limen) determinations. The usual psycho-physical procedure is followed, in that the sound is progressively weakened, on each trial, from supra- to sub-liminal intensity and vice versa. In all, four series of readings are taken—twice from strong to weak and twice from weak to strong intensities—alternately presented. The intensity of the sound is controlled by means of an attenuator[5] which is a series of resistances so arranged as to increase or decrease the sound intensity in decibel steps. The decibel is used as the sensation unit in describing the magnitude of sounds; a change in power level of a sound by one decibel is approximately the smallest that the human ear can detect.[6] A sound of some convenient intensity is taken as the standard, and is then reduced in four decibel steps. The stimuli are given usually at from three to five levels (rarely more or less) in order to procure 100 per cent response at the strongest sound level, and 0 per cent (no) response at the weakest sound level. Thus during any test, 12 to 20 readings are taken at the different intensity levels.

The limen, in absolute threshold determinations, is taken at the 50 per cent point—the point at which the probability of response is one-half—and is determined from the percentage of responses at the different levels by some form of the "method of least squares."[7] The readings are taken for a number of days until the animal's performance is quite consistent. The dog is then irradiated, and the effects are studied by subsequent testing.

The significance of any change in acuity over a period of time is determined in the

[5] For a good description see Witting, E. G. Apparatus used in recent Baltimore experiments on the physiology of the ear. *Laryngoscope*, 1932, *42*, 497–505.

[6] Fletcher, H. Speech and Hearing, 1929, p. 68 ff.

[7] Brown, W., and Thomson, G. H. The Essentials of Mental Measurement, 1925, p. 44 f. The 50 per cent point may be determined by a variety of methods (such as straight linear interpolation, the Spearman Mean Method, and the so-called Phi Gamma Function); and the limens, as determined by the different methods, do not appreciably differ.

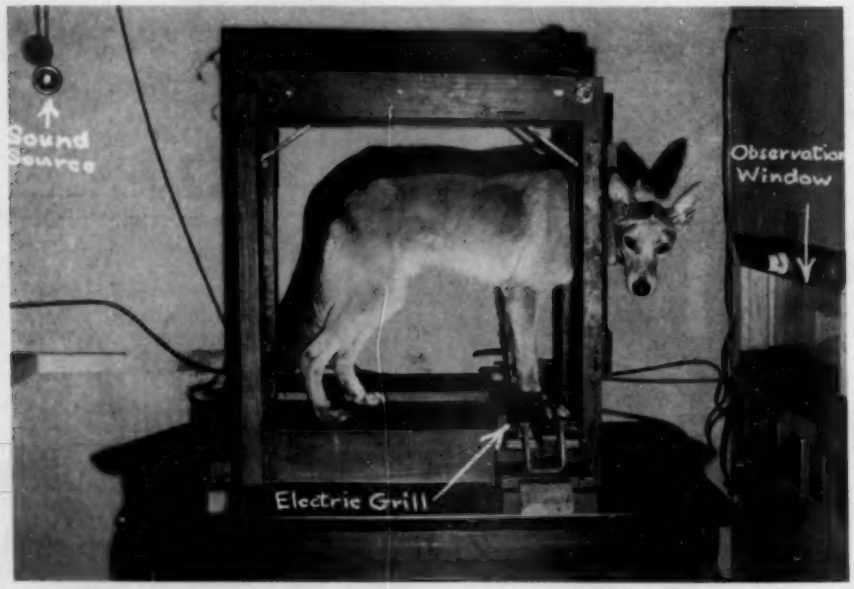

Fig. 1. Testing apparatus. A recent picture of Dog. No. 1. Loss of hair is quite evident.

usual statistical manner.[8] The readings before and after irradiating are conveniently grouped, and the means and standard deviations calculated. The standard error of the mean is obtained by dividing the standard deviation of the distribution (group) by the square root of the number of cases involved (which in this case is 10). The differences between the means are tabulated, and their standard errors determined—from which data, "t," the ratio of the actual difference (between two means) to its standard error, is calculated. By use of the proper tables[9] the significance of any "t" (for a given number of cases) is directly given in terms of P (probability value).

[8] Fisher, R. A. Statistical Methods for Research Workers 1925, chap. 5. Also reference given below.

[9] Fisher, R. A. Application of "Student's" Distribution, *Metron*, 1925, 5, 90–120. While Pearson's tables are in more common use, Fisher's are made particularly for small samples of data.

Fig. 2. Roentgen apparatus. 200 kv. Coolidge tube, "universal" type. The lead covers to limit area of exposure are not shown. (Dog No. 1 a year ago; hair still present.)

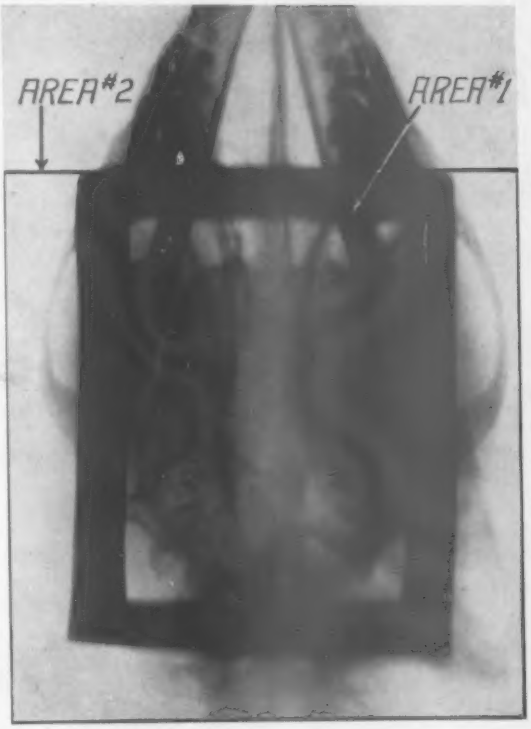

Fig. 3. Area #1: 6×8 cm., area first exposed in Dog No. 1. Area #2: 13×13 cm., area exposed in Dog No. 2.

As an example, suppose we wish to determine the significance of the first rise in acuity in Dog No. 2. In this case let us compare the two means before the rise occurs (Fig. 4) with the two immediately following. The four means with their standard errors are: 47.7 ± 1.5, 48.4 ± 0.89, 54.9 ± 0.99, and 55.2 ± 1.2. (The standard deviations of the four distributions respectively are: ± 4.7, ± 2.8, ± 3.1 and ± 3.6, and the standard errors were calculated by dividing each of the standard deviations by the square root of 10). Subtracting the first two means from each of the second pair gives the actual decibel differences: 7.2, 7.5, 6.5, and 6.8. The standard error (deviation) of each difference is the square root of the sum of the squares of the standard errors of the two means. In the case of the first and third means (47.7 and 54.9) the standard error of their difference equals the square root of $[(1.5)^2+(0.99)^2]$ which is 1.8, and "t"—

the actual difference divided by its standard error (7.2 divided by 1.8)—is 4.0. Referring to Fisher's tables[10] "t" is given directly in terms of P, which in this case is 0.0004. Repeating this procedure for the other differences, the following table is derived:

1st Mean 47.7	7.2 / 1.8 t=4.0 P=0.0004	7.5 / 1.9 t=3.9 P=0.0005
2nd Mean 48.4	6.5 / 1.4 t=4.6 P=0.0001	6.8 / 1.5 t=4.5 P=0.0001
	3rd Mean 54.9	4th Mean 55.2

When the value of P is less than 0.02 (that is, when a difference of this magnitude would occur as a result of purely *random sampling* less than 2 times in a 100) the difference is considered valid, and not due to "chance." In this example all the values of P are much smaller than 0.02, and the differences therefore quite significant.

By use of a continuous radiation Cooldige therapy tube* (mechanically rectified—rating 200 kv., 6 ma.), doses of more than five minutes were possible. The areas of radiation were carefully controlled by reference to anatomical structures in the head (such as the lambdoidal ridge) and the surrounding areas covered with lead. The animal was held securely in place by a metal container—also lead covered during irradiations—giving accurate control of the exposed area (Fig. 2).

EXPERIMENTAL CONDITIONS

Most irradiations were given at 85 kv. and 5 ma., with the exception of a few early doses to Dog No. 1 at 50 kv. Variation in line voltage resulted in a variation of ±3 kv. (as checked by sphere gap). The target distance for the most part was 25 cm. ±0.5. The roentgens as determined by the Victoreen r meter (calibrated in international units) at these values was 2.5/second. At a distance of 30 cm. with an aluminum filter interposed, the r dropped to 1.5/second. No account was taken of surface intensity (back-scattering) for all calculations were determined by direct radiation of the ionization chamber.

Dog No. 1. The first irradiations were aimed directly at the top of the head, including the area from above the eyes back to the lambdoidal ridge—distance 8 cm. and 3 cm. on each side of the median line (Fig. 3). Some doses were given at 50 kv., but upon discovering the fact that, at this voltage and 5 ma. only 0.025 r/second was being generated, the old value—85 kv.—was returned to. Irradiation started November 23, 1931, and was continued until March 11, 1932, with a total dosage of 4,500 r. The area of radiation was then changed to direct exposure of the ears at a distance of 30 cm., kilovoltage and milliamperage remaining the same. This period continued until April 6 (total r=3,350) when the animal began to be sensitive on top of the head. The beam was then filtered through 0.5 aluminum until April 16, during which time 3,250 more r accumulated. The irradiation then had to be halted because of skin burns. Originally, some silver nitrate was used in marking the dog's head, which may have had something to do with the loss of hair in this animal. The total dosage for this animal was over 11,100 r.

Dog No. 2. In this animal 85 kv., 5 ma., and a target distance of 25 cm. was used for all irradiations. Comparatively larger doses were used, beginning with an exposure to 75 r, and concluding with four 1000 r doses. A somewhat larger area was irradiated: the entire width of the skull (13 cm.) and from above the eyes caudally 13 cm. to the spinal cord (Fig. 3). The first dose was given January 23, 1932, and the last one June 10. The total cumulation was over 4,400 r. No silver nitrate was used on this dog, but in March it, too, showed signs of "baldness."

[10] *Ibid., Metron*, pp. 114–120.

* The authors wish to express their indebtedness to Professor G. L. Clark for making available the facilities of the X-Ray division of the University of Illinois, and to Dr. K. E. Corrigan, for his kind assistance and suggestions in the irradiation of the animals.

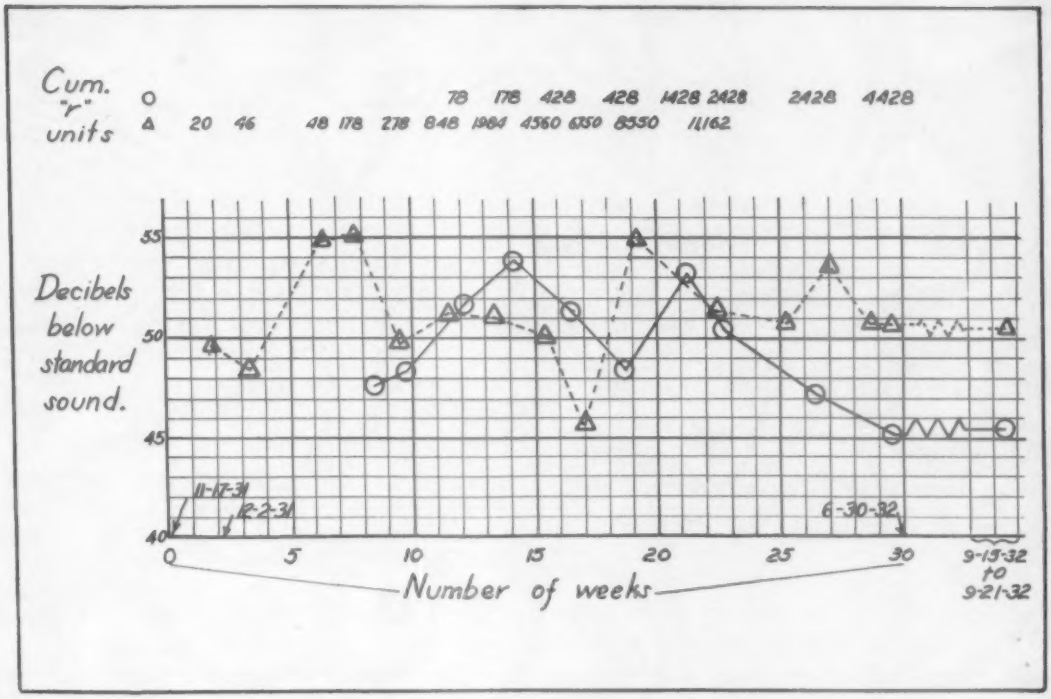

FIG. 4. 1. Dog No. 1 indicated by Δ – – – Δ and Dog No. 2 indicated by ⊙——⊙ 2. Each Δ and ⊙ represents a mean of 10 consecutive tests except in the last case (September, 1932); for Δ it is an average of 6, and for ⊙ it is an average of 11 cases. 3. Dog No. 1 started November 17, 1932, and Dog No. 2 December 2, 1932, as indicated.

RESULTS

In both cases there is a transient *increase in auditory acuity* lasting some four weeks, followed by a relapse to normal. The animals were under continued exposure to roentgen rays, so that there are no accurate data on the true duration of this increase in acuity in these animals.[11] The acuity of Dog No. 2 dropped 2 decibels for the last twenty-odd tests, taken through June and September. This may be accounted for by the continued presence of skin burns, and the concomitant difficulty in testing the animal. The acuity of Dog No. 1 never stayed significantly low, though at one time (March: about the 17th week on the graph) the readings showed a downward trend, which after a while returned to the normal level.

Both animals showed apparent manifestations of "nervousness," both in their general behavior as well as during test periods. Up until last December (at which time Dog. No. 2 was despatched during another experiment) both animals appeared to be quite "normal," the single incongruity being the lack of hair on top of their heads. Dog No. 1 at present is, however, quite emaciated and the blood in poor condition. The normal blood count of this animal last year was: red blood cells 5,500,000 and white blood cells (leucocytes) 12,000—which is within the limits of normal variability in dogs. Recent examination showed the red blood count to be about 3,500,000, and the white blood count to be 6,500, both much below normal. Recent tests indicate that this animal's hearing is still normal.

[11] Further data on different animals have been gathered with respect to this initial rise in acuity, and are at present being checked by use of control groups of animals: that is, irradiating one animal and not the other.

Examination of the graph will show a second rise in acuity in both dogs. This is much more transient than the first; in Dog No. 1 it lasted for about 10 days, and in Dog. No. 2 lasted about 15 days. As yet, no further work has been completed on new animals under comparable conditions.

At 85 kv. and 5 ma., 1,200 r seems to be the maximum dose that can be given in a two week period without subsequent development of skin burns. Although the total cumulated dose in Dog. No. 2 was much less than that of Dog No. 1 (4,500 to 11,100) the skin burns showed up sooner in Dog No. 2. The explanation is possibly two-fold: in the first place, the area of exposure in Dog No. 2 was larger (169 sq. cm. to 69 sq. cm. for Dog No. 1[12]) and secondly, the last two doses for Dog No. 2—1000 r each—were but nine days apart. The skin burns in the latter began to appear a week after the second of these two doses. Dog No. 2, up until the time of his death in December, never recovered from the skin burns, whereas Dog No. 1 at present shows no signs of them at all. Most of the burns in the latter animal disappeared as early as last September. There is, too, some indication of the hair reappearing in this animal.

[12] Kaplan, I. I. Practical Radiation Therapy, 1931, p. 91: "... there may ... be as high as 30% increase in surface intensity by changing the field from 5×5 to 20×20 cm."

SUMMARY

The conditioned response technique is suggested as a means of direct study of the effects of roentgen rays upon hearing in dogs. By means of this approach accurate investigation of the effects of roentgen rays upon hearing itself is permitted. In the animals reported on, as well as in subsequent studies nearing completion, an initial rise in auditory acuity results from exposure to small doses of roentgen rays generated at 85 kv. and 5 ma. This increase in acuity is a transient effect lasting from two to four weeks.

Cumulated doses up to 11,100 r in one animal and over 4,400 in another resulted in neither a fatality nor impaired hearing. The skin burns were due to overexposure to soft rays. Spacing of the larger doses over longer periods of time avoids this hazard.

The investigation is being widened to include the study of the effects at higher voltages, and also, by means of the oscillograph technique, the direct effect on the nervous mechanism involved in audition.

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EFFECTIVE APPLIED VOLTAGE AS AN INDICATOR OF THE ENERGY EMITTED BY A ROENTGEN-RAY TUBE*

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ABSTRACT

A previous study[1] suggested a parallelism between the applied effective voltage and the emission of a roentgen-ray tube. The investigation has been carried further under more carefully controlled conditions. It is found for two mechanical rectifiers and one "constant potential" generator that the roentgen-ray emission per *effective* (*root-mean-square*) *milliampere* of tube current is about the same for all generators operating at the same *effective* (*r.m.s.*) *voltage* (the radiation passing through the same filter in all cases). Thus it becomes possible to express all radiations in terms of that excited by constant potential. This leads to a simplification in the description and reproduction of irradiation conditions in biological work. Although the study has been limited to three generators, it is believed that they are sufficiently typical of other types to warrant generalization.

I. INTRODUCTION

IN A recent study the energy emitted by a roentgen-ray tube, as measured by an ionization chamber, was found to be very different when excited by different types of high tension generators furnishing the same average tube current and *peak voltage* (as measured by a sphere gap). But it was further found that for the same average currents and the same *effective voltage** of the generators, the emission, as measured by the ionization chamber, is approximately the same.

The total energy in a roentgen-ray spectrum devoid of characteristic lines varies as the square of the instantaneous applied voltage, and hence for a known voltage wave form the total energy and its wave length distribution, for the period of a complete cycle, is calculable. Because of the presence of tungsten line radiation above 70 kv., it is not yet practicable to predict the total roentgen-ray energy by integrating over one cycle of the voltage wave. In the present work the roentgen-ray emission per unit tube current, as it varies with peak voltage, with average voltage and with effective voltage per unit tube current, is given for more carefully controlled and wider ranges of conditions. This is expressed in terms of the roentgen-ray *emission per milliampere*.

II. APPARATUS

Thus far three generators have been used, designated by *A*, *B* and *C* as in the preceding work.[1] *A* is a full wave mechanical rectifier having a single high tension transformer, and rectifying over approximately 30 degrees of cycle; *B* is also a full wave mechanical rectifier but with a divided high tension transformer, and rectifying over approximately 20 degrees of the cycle; *C* is a valve tube-condenser ripple potential* generator (so-called "constant potential") having a ripplage of about 2

* Second part of paper presented at meeting of American Association for Advancement of Science and the American Roentgen Ray Society, Syracuse, N. Y., June, 1932.

[1] Taylor, L. S., and Tucker, K. L. *Bur. Standards J. Research*, 1932, *9*, 333 (RP 475). Also: Am. J. Roentgenol. & Rad. Therapy, June, 1933, *29*, 826–843.

* Effective voltage is mathematically the same as root-mean-square (r.m.s.)voltage.

* The term "constant potential" has been used loosely to describe the potential supplied by kenotron or other valve tube rectification. A more accurate designation of voltage which is not constant in fact but fluctuates slightly about a certain average value is "ripple voltage." Thus by a "ripple quantity" (potential or current) is meant a simple periodic quantity $y = V_0 + V_1 \sin(\omega x + \alpha_1) + V_2 \sin(2\omega x + \alpha_2) + \cdots$ in which the constant term (V_0) is so large that all values of the quantity are positive (or negative). The amount of ripple ("ripplage" or "ripplance") in a ripple quantity is the ratio of the difference between the maximum and minimum values of the quantity to the average value.

These definitions are under consideration by the Committee on Electrical Definitions of the American Standards Association under the sponsorship of the A.I.E.E.

per cent per milliampere. The three generators could be interchangeably connected to the roentgen-ray tube.

1. Current Measurements

The arrangement of the apparatus is indicated in Figure 1. *Average* current through the tube is measured in the usual manner by a d.c. milliammeter *A;* and the *effective current* by an a.c. milliammeter, *B.* For this purpose, a thermo milliammeter alone was available. This was protected from high frequency oscillations by iron core chokes, *L,* having a d.c. resistance of a fraction of an ohm; a noninductive resistor, *T,* of about 10,000 ohms, and a 1/20 μf capacitor, *C.* Since the resistance of the meter, *B,* was only about 20 ohms, this shunt system served as a very effective filter against high frequency oscillations in the high tension system, without affecting the sensitivity.

Excessive high frequency oscillation when using the mechanical rectifiers caused difficulty in peak voltage measurements with the sphere gap but this was largely eliminated by placing inductively wound surge resistors, r_2, immediately next to the rectifier switches, giving smoother operation of the equipment and more consistent peak voltage measurements. After raising the generator voltage sufficiently to compensate for the potential drop across the resistors, it was found that their presence did not alter the tube output in any way.

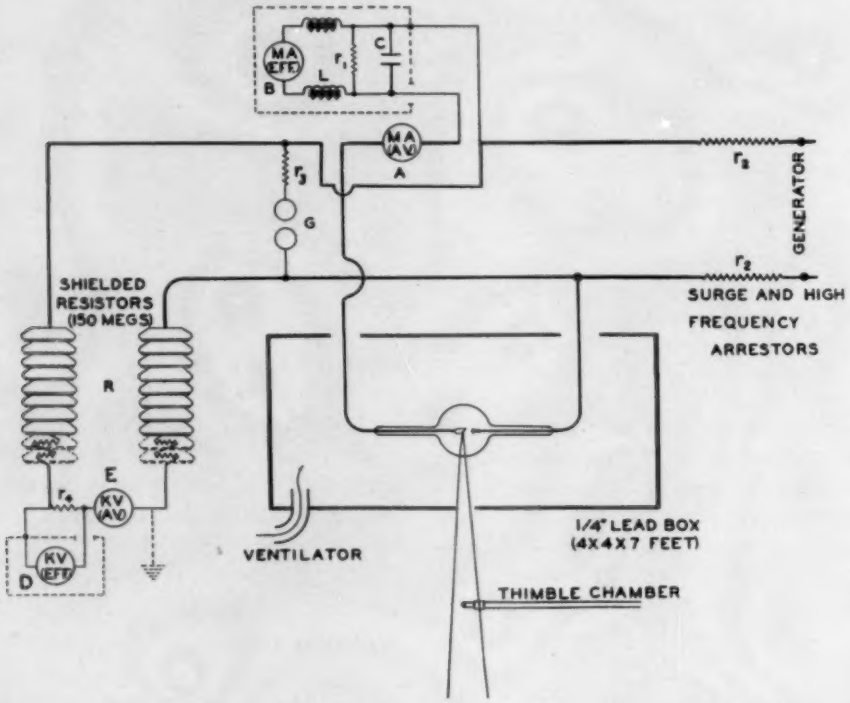

Fig. 1. Diagram of apparatus showing voltage and current measuring equipment.

With generator *C,* the same resistors were used for the purpose of limiting the current in case of slight tube gassiness or when using a sphere gap for measuring the voltage. It was found that they raised the voltage limit very materially at which a given tube would operate satisfactorily.

2. Voltage Measurements

Peak voltage of all three generators was measured by the gap between 12.5 cm. spheres, protected by a water resistance, r_3, to prevent heavy arcing at the gap and

consequent tripping of circuit breakers.

Average voltage was measured by means of a d.c. microammeter, *E*, in a series with a shielded high voltage resistor of 150 megohms,[2] the meter being at the center of the resistance so as to be at or near ground potential.*

Effective voltage was measured by means of a 150-volt calibrated Kelvin multicellular electrostatic voltmeter, *D*, shunted across a resistance, r_4, of 75,000 ohms. Since its potential was likely to be different from ground, it was necessary to shield it by a metal case having the same potential as one of its terminals.

It should be stated here that the insertion of the high voltage resistor, *R*, across the line has no noticeable influence upon the operation of the high tension generators because the current it shunts off is very small. This fact is of course essential since a wave form very different from that under normal operating conditions may otherwise result.

3. Radiation Measurements

The roentgen-ray emission was measured by means of a thimble chamber kept in a fixed position with respect to the tube throughout the study. The beam was in all cases filtered by 0.525 mm. of copper, the wall effect of the chamber being negligible for the transmitted radiation.

No other determination of radiation quality was undertaken, as the previous study[1] indicated what was to be expected under the operating conditions employed here, namely, all beams having the same effective voltage and filtration and giving equal intensities have approximately the same quality (whether expressed in the half-value layer of copper, copper absorption coefficient or effective wave length).

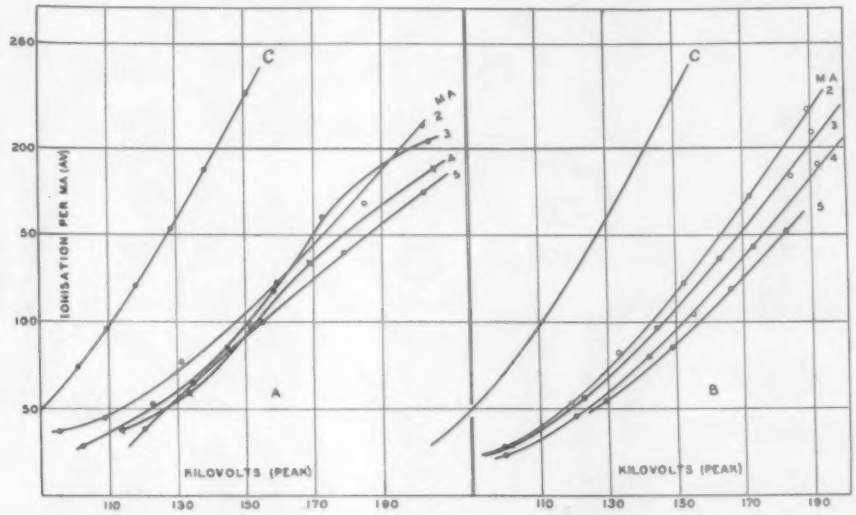

FIG. 2. Relationship between roentgen-ray tube emission, for average milliampere, and the applied peak voltage. *A*, *B*, mechanical rectifiers; *C*, constant potential.

III. EXPERIMENTAL RESULTS

In this study, to eliminate the effect of variation in operation, simultaneous values were obtained for (1) average current, (2) effective current, (3) peak voltage, (4) average voltage, (5) effective voltage and (6) roentgen-ray tube output for a constant filtration of 0.525 mm. of copper, the average current (the quantity measured in practice) serving as independent variable.

[2] Taylor, L. S. *Bur. Standards J. Research*, 1930, 5, 609 (RP 217).

* The voltage on the high tension conductors is seldom divided equally above and below ground potential, although the error in measurement introduced by grounding the resistor at the center is very small.

In Figure 2, groups *A* and *B* show the tube emission, expressed in terms of the ionization current per average milliampere (I/ma. (av.)), as a function of peak voltage for generators *A* and *B*, respectively, and for different tube currents, 2, 3, 4, 5 ma. With generator *B* it is seen that for a given peak voltage, the value of I/ma. (av.) varies from 10–15 per cent in changing the operating tube current by 1 ma. This is not unexpected since the generator wave form depends to a large extent upon the power drawn from the generator. It is obvious from these curves that it may be very misleading to attempt to deduce the emission of a roentgen ray tube from current and peak voltages alone. For generator *A*, I/ma. (av.) varies erratically with peak voltage under different operating currents.

Figure 2, curve *C* in both groups is from generator *C* ("constant potential") for a tube current of 4 ma. Since the peak voltage of this generator does not vary appreciably with tube current (average voltage being kept constant), a single curve embodies the results. It is seen that for the same peak voltage there is a large difference between the roentgen-ray emission of generator *C* (curve *C*) on the one hand and that of generators *A* and *B* (curves *A* and *B*) on the other. To obtain the same roentgen-ray emission from generators *A* and *B* as from generator *C*, the peak voltage of *A* and *B* must be very much larger than that of *C*, depending upon the operating current.

If, for the same radiations plotted in Figure 2, we plot instead the ionization per

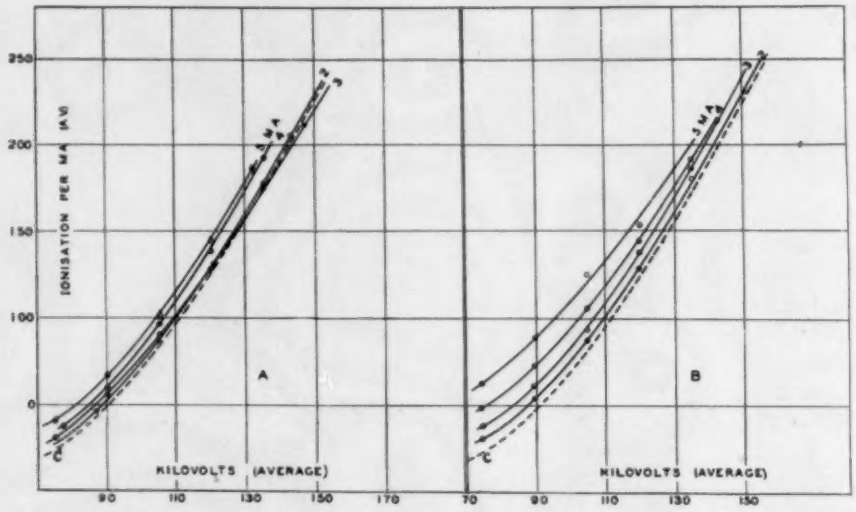

FIG. 3. Relationship between roentgen-ray tube emission, per average milliampere, and the applied average voltage. *A*, *B*, mechanical rectifiers; *C*, constant potential.

average milliampere against the *average voltage*, corresponding curves, *A*, *B*, and *C*, in Figure 3 are obtained. It will be noted that I/ma. (av.) again varies with the tube current. In the case of generator *A* the values of I/ma. (av.) vary from about 2–8 per cent in changing the operating current by 1 ma. This percentage change becomes smaller, however, in going to higher average voltages, whereas, when the potential is measured in peak kilovolts, the changes become larger at higher voltages.

In the case of generator *B* the same general results obtain. The variation of I/ma. (av.) with tube current at a given average voltage is, however, much greater at lower potential than for *A*, while at higher potentials it is about the same.

It is seen that, while the curves for *A* and *B* differ with tube current, they all lie in

the region of curve *C* (dashed) as contrasted with the corresponding curves of Figure 2 for peak voltages. Thus, if the current and voltage for all three generators be measured in terms of average milliamperes and average kilovolts (that is, by using d.c. instruments), the tube emission per milliampere is in all cases of the same order of magnitude.

is present but again to the least degree.

Of prime importance, however, is the fact that the curves (Fig. 4) for both generators *A* and *B* lie very closely along the curve for constant potential—much more closely at the higher voltages than those in Figure 3 for average current and voltage measurements. It is concluded that, for equal effective roentgen tube currents and

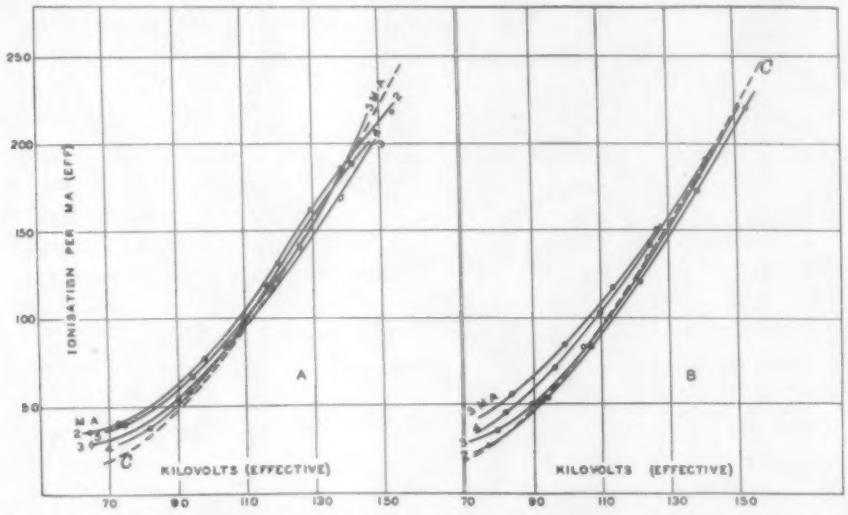

Fig. 4. Relationship between roentgen-ray tube emission, per effective milliampere, and the applied effective voltage. *A*, *B*, mechanical rectifiers; *C*, constant potential.

Using *effective* milliamperes and *effective* kilvolts, curves for generators *A*, *B*, and *C* for the roentgen-ray emission per effective milliampere are given in Figure 4.

It should be pointed out that for the comparatively small ripplage present in the voltage of generator *C*, the difference between the average and effective voltage is so small that it may be neglected. Likewise their variation with tube current is negligible; hence, a single curve for I/ma. (eff.) gives a satisfactory basis of comparison.

In the case of generator *A* the change in emission per milliampere, as the operating current is varied, is present and somewhat erratic as in the case of the peak voltage curves. The percentage change, however, is the least of the three cases given. Similarly in the case of generator *B* the change

equal effective voltages, the emission per milliampere will be sufficiently near the same with all three generators for the effective current and voltage to be used as characteristic of the roentgen-ray emission.

Since the emission per milliampere for all strictly constant potential generators is the same, it is logical that it be referred to as a base. By means, then, of the effective current and effective voltage measurements described, it is possible to relate consistently the roentgen-ray emission excited by the various types of generators.

It is possible to trace the residual variation in roentgen-ray emission per milliampere at lower voltages with the operating current largely to the current-voltage characteristics of the roentgen tube. This will account also for the divergence from the constant potential base line. Figure 5

shows for various applied constant potentials the tube current curves for three values of the filament current, I_f. It is seen that, since the tube current is still increasing about 5 per cent per 30 kv. at 120 kv., saturation is not attained. Consequently,

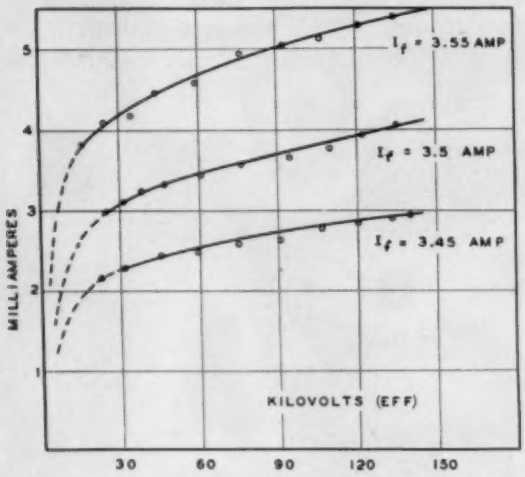

FIG. 5. Tube current—tube voltage characteristics.

with the application of a varying voltage to the tube, the effective current is bound to depend upon the voltage wave form to a varying degree.

This is illustrated in Figure 6 where curves *a* and *b* are two hypothetical tube current characteristics, the second of which is ideal in that it reaches saturation at a comparatively low voltage. Curves *D*, *E*, and *F* represent three types of generator voltage wave form having the same effective voltage, *c*, which, when applied to tubes having characteristics *a* and *b*, produce the tube current wave forms *a'* and *b'* respectively for each associated voltage wave. In each of the cases it is seen that the effective current i_a for tube characteristic *a* is lower than the effective current i_b for characteristic *b*. Moreover the magnitude of this difference depends upon the generator voltage wave form as shown.

To compare the explanation above with the results found, we note that the experimentally determined tube characteristics in Figure 5 are similar to *a* in Figure 6; hence, the tube current measured in effective amperes is less than it would have been had the tube reached saturation at as low voltage as for characteristic *b*.

In Figure 4 the emission per effective milliampere—which is plotted against effective kilovolts—would accordingly have been less with an ideal characteristic such as *b*. In other words, the curves plotted would have fallen more nearly along the constant potential curve *C* (Fig. 4).

To show the relationship between peak and effective kilovolts for different tube currents, the curves *A* and *B* in Figure 7 were obtained for the correspondingly designated generators. The straight dashed lines in each set of curves represents the ratio of peak to effective voltage (kv. (peak) = 1.41 kv. (eff.)) for a sine wave.

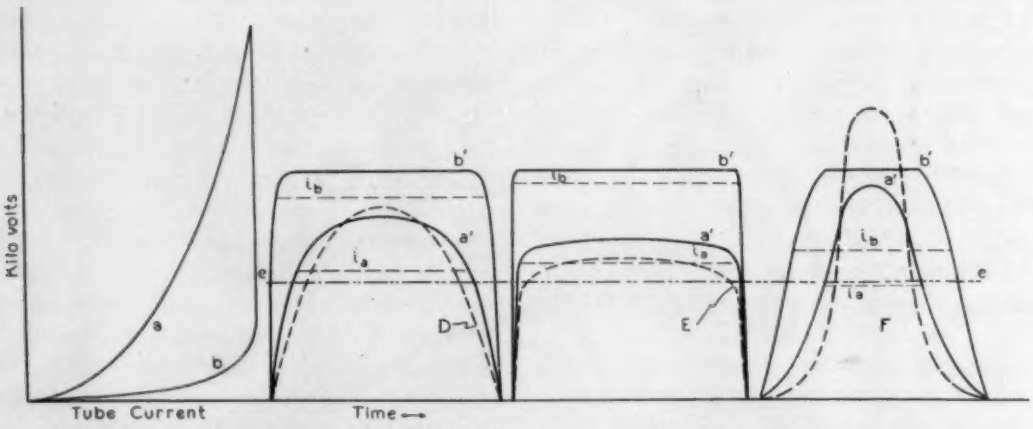

FIG. 6. Effect of tube characteristic and generator wave form on the effective tube current.

It is seen that there is no simple relationship between the two voltage measurements as in the case of a sine wave.

Such a set of curves is very useful when interpreting the behavior of a particular generator under different conditions. This was demonstrated in some earlier work* when comparing the output of generators *A* and *B*.

volved in the therapeutic use of high voltage roentgen rays. The greatest single factor contributing to this has been the voltage measurement, since it has been sometimes assumed that a given roentgen tube, activated by the same voltage (by sphere gap measurement) and passing equal average currents, should yield the same roentgen-ray emission for all similar

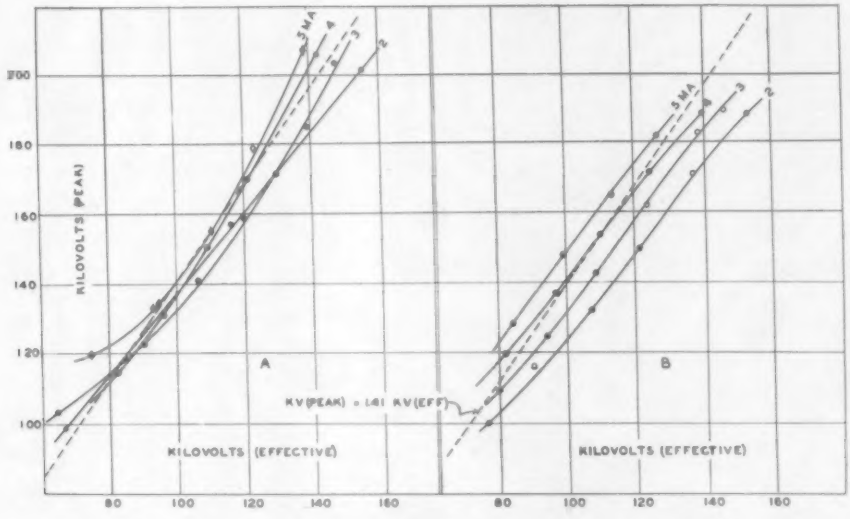

Fig. 7. Relationship between peak and effective kilovolts for two mechanical rectifiers.

The curves also furnish some inference as to the generator wave form, particularly above the point where the tube current characteristic plays an important rôle. Thus, where the points lie below the line kv. (peak) = 1.41 kv. (eff.), they indicate a flat-topped voltage wave form relative to a sine wave; where they lie above that line, a relatively narrow or peaked wave form is indicated. These relations, though only qualitative, are of help in properly adjusting the phase position of the switches on a mechanical rectifier for optimum roentgen tube emission.

IV. Discussion

There has been considerable confusion in interpreting the physical magnitudes in-

* See Figure 16 with explanation in paper by L. S. Taylor and K. L. Tucker (Footnote 1).

generators. We have shown here, however, that the emission may differ by ±20 per cent under supposedly like conditions.

Although a difference existing between mechanical and constant potential rectifiers has been generally recognized, there has been uncertainty as to any exact relationship between them, with the result that few attempts have been made to correlate treatment factors for the two machines. There has even been a belief that the radiation of one could not be clinically reproduced by the other. The experiments described here show that both generators may be made to produce the same emission (as far as may be deduced from absorption measurements in copper or paraffin) when the tube potentials are properly adjusted.

The present study has been limited thus far to mechanical and "constant potential"

rectifiers. While it is believed by some that mechanical rectifiers will probably be displaced by valve tube rectifiers, the study is of no less value, since with the great variety of valve tube circuits in use there is an equal variety of voltage wave forms produced none of which may be readily correlated as far as they affect the roentgen-ray output of a tube. For example, in addition to "constant potential" there will be half-wave, full-wave, and polyphase rectifiers and voltage doubling circuits such as the La Tour and Villard systems. In some of these the wave form depends upon load to a greater extent than others and, as a consequence, measurements of peak voltage alone will lead to similar discordance now encountered in mechanical rectifiers.

This study reveals that, when the generator potential is measured in effective kilovolts, the roentgen-ray emission of a tube is equivalent to that produced by very nearly the same constant potential. It is thus possible to express the emission in terms of that obtainable from a constant potential source.

Expressing tube potential in effective kilovolts simplifies the method of expressing radiation quality. For example, when describing radiation quality in terms of the "half-value layer of copper" it is recognized as necessary also to state the voltage. However, as voltages are now measured, even this is inadequate due to the effect of wave form. To indicate quality correctly by the usual absorption methods, the effective voltage should be stated—not the peak voltage.

The cordial cooperation of the Radiological Research Institute and of the American x-ray equipment manufacturers in this work has been very helpful.

ROENTGEN-RAY OUTPUT COMPARISONS OF THERAPY CIRCUITS AND TUBES*

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CHICAGO, ILLINOIS

THE purpose of this article is to compare the more common types of generating circuits and tubes for therapy use on the basis of roentgen-ray output per given sphere gap kilovoltage and average (meter read) milliamperage. A number of articles on this subject have been written in the last few years but most of them have taken into consideration only one type of roentgen tube and two or, at the most, three circuits. In addition, at least some of the data must be discounted because factors which influence the result have either been overlooked or not completely specified.

APPARATUS AND METHOD

Throughout the entire study as many variables as possible were eliminated by keeping the same overhead system, tube enclosure, dosimeter enclosure, dosimeter, sphere gap, milliammeters, high voltage transformer, primary control, and power supply (Fig. 1). The same operators took data throughout. Arrangements were made whereby it was possible to change from one circuit to another within fifteen minutes. In this way it was possible to make repeated checks with all combinations of circuits and tubes within a short enough time to eliminate the variables of temperature and barometric pressure. Two high voltage transformers, 5 filament transformers, 4 kenotrons, a 0.05 microfarad bank of condensers, and a cross arm mechanical rectifier switch, made possible the following generating circuits (Fig. 2):

(a) Mechanical rectifier for 200 kv.p., 30 ma.

(b) Half-wave rectified kenotron for 250 kv.p., 30 ma.

(c) Full-wave bridge kenotron for 200 kv.p., 30 ma.

(d) Kenotron condenser voltage doubling circuit for 300 kv.p., 10 ma.

(e) Kenotron condenser voltage tripling circuit for 300 kv.p., 10 ma.

(f) Constant potential doubling circuit for 200 kv.p., 25 ma.

Eight different types of therapy tubes representing several different manufacturers were used in the study.

Measurements in roentgens were made with a Victoreen thimble type removable chamber dosimeter. The dosimeter was checked with the manufacturer's standard several times during the study.

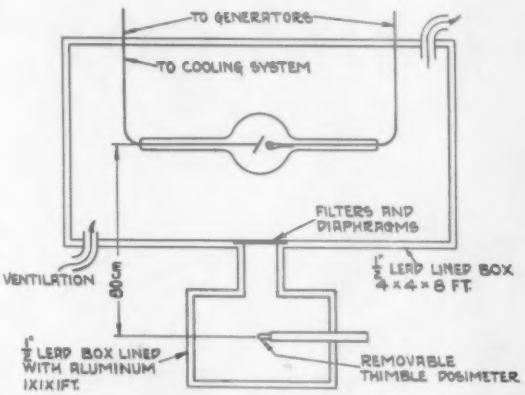

FIG. 1. Diagram of the apparatus showing the tube container and ionization measuring system.

DATA AND CONCLUSIONS

Figures 3, 4, 5, 6, 7 and Table 1 summarize an r comparison of circuits and tubes.

Figure 8 gives a half-value layer comparison of circuits. Data for Figure 8 are obtained from Figure 5.

Table II gives a comparison of the kilovolts peak, and milliamperes required on different circuits and with different tubes to obtain as nearly as possible identical radiation.

From the data it is quite obvious that constant potential gives a greater output

* From the Tube Department, General Electric X-Ray Corporation, Chicago.

than any other type of circuit when the comparison is made on the basis of kilovolts peak, and milliamperes. Qualitatively, this fact is well known. Quantitatively, wide differences have been reported.

The tripling (Witka) circuit is second in order of output to constant potential. Because of other limitations, however, this circuit has found little commercial application.

The voltage doubling (Villard) circuit is third in order of output. It is being extensively used for very high voltage because with the circuit only about one-half of the roentgen tube voltage needs to be supplied by transformers.

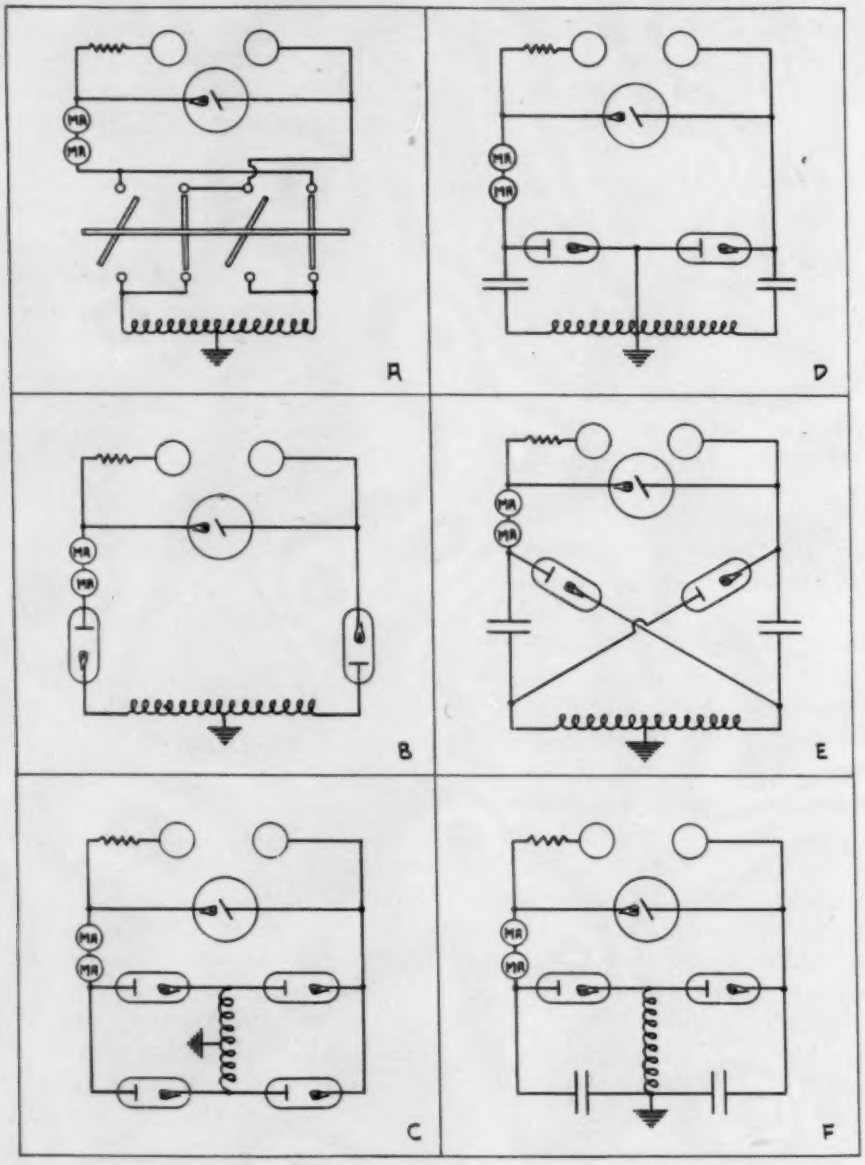

FIG. 2. Diagrams of circuits used in the investigation: (*A*) mechanical rectifier; (*B*) half-wave circuit; (*C*) full-wave circuit; (*D*) voltage-doubling circuit; (*E*) voltage-tripling circuit; (*F*) constant potential.

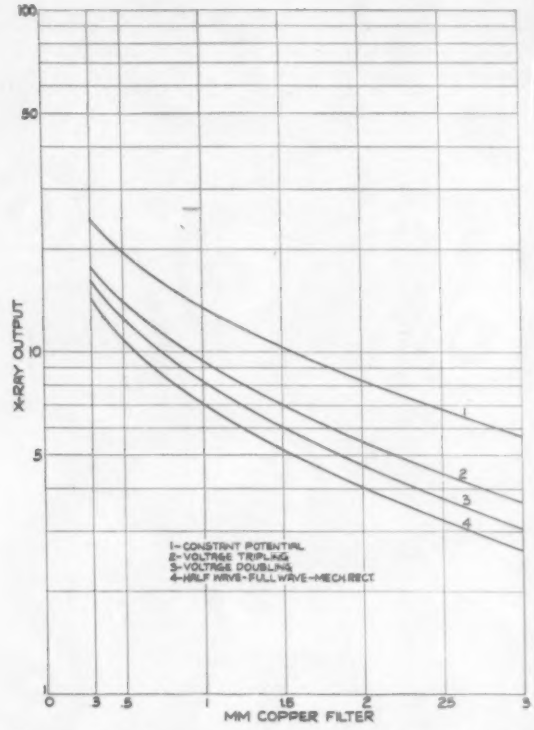

Fig. 3. Roentgen-ray output comparison of circuits: 200 kv.p., 10 ma., water-cooled therapy tube with one-quarter inch glass filter, total anode radiation.

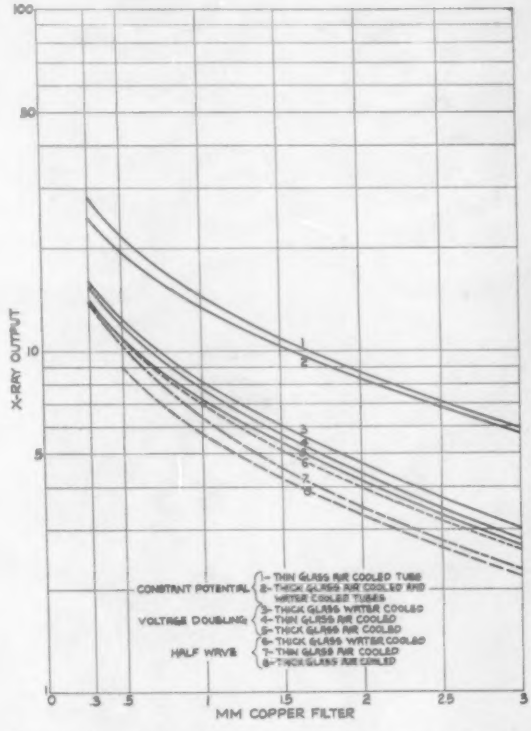

Fig. 4. Roentgen-ray output comparison of circuits and tubes: 200 kv.p., 10 ma., total anode radiation.

No significant differences in r output or quality are found between mechanically rectified, full-wave kenotron, or half-wave kenotron rectified circuits, that is, no differences greater than 5 per cent. It might be noted that this agrees with conclusions reached in the diagnostic range of voltages to the effect that these same circuits are of equal roentgenographic speed for all practical purposes. Differences may be found where equipment of different manufacture are compared, and where different overhead systems, tubes and power supplies are used.

Any quantitative comparison of different circuits depends upon the type of tube

Table I

Quantitative comparison of circuits on the basis of r output at 200 kv.p., 10 ma.

Circuit	Tube (Water-Cooled or Air-Cooled)	Ratio of r output to that obtained on constant potential			
		0.5 mm. Copper	1.0 mm. Copper	2.0 mm. Copper	3.0 mm. Copper
Constant potential	Water-cooled	1.0	1.0	1.0	1.0
Constant potential	Air-cooled	1.0	1.0	1.0	1.0
Voltage doubling	Water-cooled	0.64	0.60	0.56	0.52
Voltage doubling	Air-cooled	0.56	0.53	0.50	0.46
Half-wave*	Water-cooled	0.55	0.51	0.48	0.45
Half-wave	Air-cooled	0.45	0.42	0.40	0.38

* Full-wave and mechanical rectifier approximately same as half-wave.

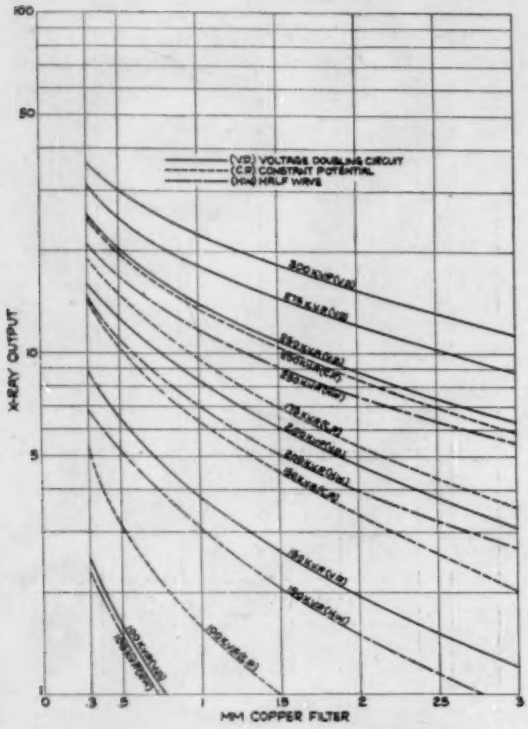

FIG. 5. Copper absorption curves for various generators. Water-cooled therapy tube with one-quarter inch glass filter, 10 ma.

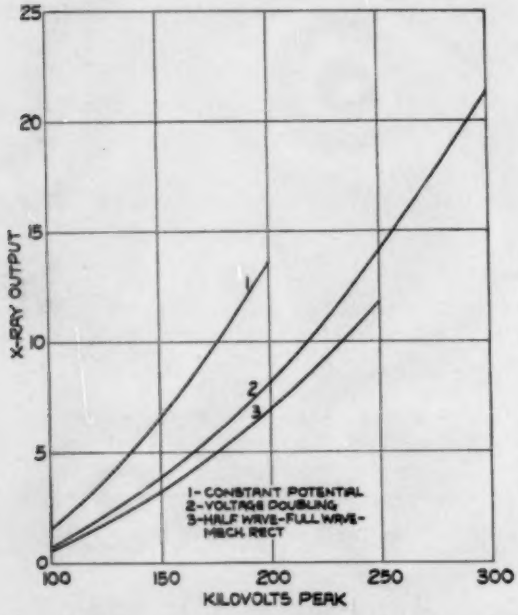

FIG. 6. Roentgen-ray output as a function of the kilovoltage peak on different circuits. Water-cooled therapy tube with one-quarter inch glass filter, 1 mm. of copper external filter.

used (Fig. 4). For example, it will be noted that a half-wave rectified circuit with a water-cooled therapy tube gives approximately the same output per ma. as a

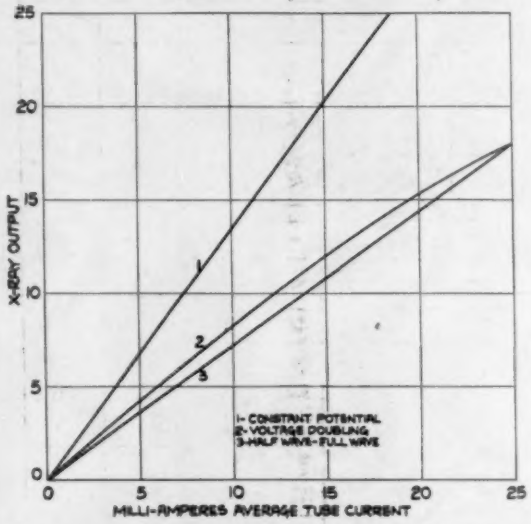

FIG. 7. Roentgen-ray output as a function of average tube current. Water-cooled tube with one-quarter inch glass filter: 200 kv.p., 1 mm. copper external filter.

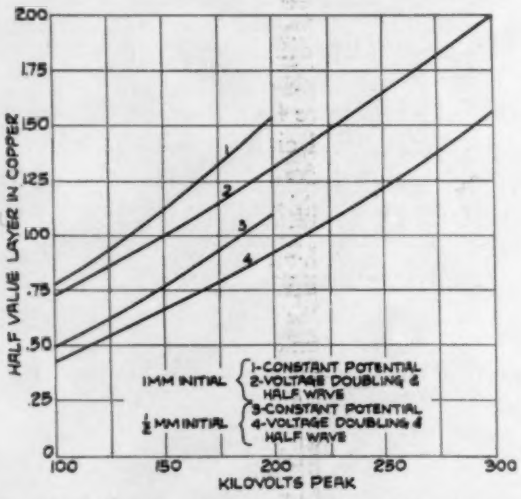

FIG. 8. Half-value layer comparison of circuits as a function of kilovoltage peak. Water-cooled tube, one-quarter inch glass filter.

voltage-doubling circuit with an air-cooled tube. On the other hand, a half-wave circuit with an air-cooled tube gives only 70 per cent the output of a doubling circuit with a water-cooled tube.

Two factors cause variation in r output from different types of tubes operating on the same circuit. The most obvious of these is glass absorption, which with the tendency toward thick glass may lower the output as much as 10 per cent. A one-quarter inch thick glass envelope of pyrex has an equivalent copper absorption at 200 kv.p. of approximately 0.2 mm. of copper. Inasmuch as a filter is always used in therapy this inherent filter in the tube offers no disadvantage. It should, however, be taken into consideration.

The second factor is distortion in wave form of the current and voltage caused by the tube itself. A recent article[1] has shown that the grid action of stray electrons on the envelope of an air-cooled therapy tube causes a gradually decreasing r output until a constant glass temperature is reached. After this stable condition is reached its r output per ma. may be from 10 to 20 per cent lower than that of a water-cooled tube.

[1] Gross, M. J. Transient K.V.P. and r output from an air-cooled therapy tube, *Radiology*, Jan., 1933, *20*, 14–17.

Measurements on a number of air-cooled therapy tubes from several different manufacturers indicate that they all fall into one class as far as amount of distortion is concerned. Any differences in r output are found to be due to variations in glass absorption.

On a constant potential source of voltage there can be no wave form distortion and this factor is eliminated, all tubes giving the same r output except for differences due to glass absorption (Fig. 4).

TABLE II

KILOVOLTAGE PEAK AND MILLIAMPERAGE NECESSARY TO DUPLICATE THE HALF-VALUE LAYER AND QUANTITY OF RADIATION OBTAINED FROM A CONSTANT POTENTIAL CIRCUIT AT 175 kv.p., 5 ma.

Circuit	Tube	Initial Filter for Half-value Layer	kv.p.		ma.	
			Sphere Gap	Per Cent Increase over Constant Potential	Average Current	Per Cent Increase over Constant Potential
Voltage doubling	Water-cooled	0.5	202	15	5.7	15
Voltage doubling	Water-cooled	1.0	205	17	5.5	10
Voltage doubling	Air-cooled	0.5	202	15	6.7	34
Voltage doubling	Air-cooled	1.0	205	17	6.3	25
Half-wave	Water-cooled	0.5	202	15	6.7	34
Half-wave	Water-cooled	1.0	205	17	6.4	28
Half-wave	Air-cooled	0.5	202	15	7.9	58
Half-wave	Air-cooled	1.0	205	17	7.6	52

SUMMARY

It is realized, of course, that these comparisons allow no conclusions to be drawn as to the relative merits of the circuits and tubes without additional knowledge as to the maximum kilovoltage and milliamperage each will stand, their reliability, first cost, life, and many other factors. It is thought, however, that the data given may eliminate confusion and make possible, to some extent at least, a better comparison of techniques on different equipments and tubes.

THE PHYSICAL FOUNDATIONS OF CHEST ROENTGENOGRAPHY*

PART I

By R. B. WILSEY
ROCHESTER, NEW YORK

WITHOUT question, the chest offers one of the most complex problems in roentgenographic technique of any part of the human body. Many of the requirements for a satisfactory chest roentgenogram conflict with each other, so that a gain in one respect is apt to be accompanied by a loss in another. It is to be expected that the relative merits of the various factors involved would be judged differently by different workers in this field, and that there would be a wide variance of opinion as to the most suitable compromise of these factors, giving the best all-round quality of roentgenogram for diagnostic purposes.

The importance of the roentgen examination in the diagnosis of chest conditions has led to serious effort to improve the technique of chest roentgenography, in the hope that it could be made to yield more exact and complete information, particularly in doubtful cases. In order to attack this problem most effectively, it seems desirable to analyze the situation in the light of the underlying physical principles, examining critically the influence of each technical factor and the various combinations of factors so far as such information is available or can readily be obtained.

Much remains to be done in the precise determination of the laws governing the various technical factors in chest roentgenography and in securing the fundamental data upon which any final solution of the problem must rest. The present study must therefore be confined to the significance of the main physical phenomena involved, omitting many refinements of secondary interest. For instance, the following statements are known to be only approximations to the truth; they are sufficiently reliable, however, to justify the conclusions that will be drawn from them: (1) Roentgenographic exposure should be increased in proportion to the square of the target-film distance. (2) The correct exposure for chest roentgenograms in milliampere-seconds varies inversely as the cube of the tube voltage. (3) For any given exposure time, the energy that can safely be applied to the focal spot is proportional to the area of the focal spot. These and other approximate laws will be used in the various phases of this study.

For the purpose of giving information about the structures portrayed, the quality of the roentgenographic image is determined chiefly by two factors, contrast and definition or sharpness. Knowledge of a third factor, magnification, or variation in magnification causing distortion, is also important in the estimation of dimensions in the structures examined. Distortion in the roentgenographic image is less important than either contrast or definition, and is a much simpler problem than the others. Distortion, therefore, will be discussed first.

DISTORTION

The various parts of the subject roentgenographed are enlarged according to the geometry of shadow projection (Fig. 1), the parts farthest from the film being enlarged the most. This variation in the enlargement of different parts of the subject constitutes distortion. Distortion is lessened by increasing the target-film distance, but cannot be entirely eliminated by this means. The relations between object-film distance, target-film distance, and distortion in the single roentgenogram have been treated quite thoroughly by Andrew and Warren.[1] For the present purpose, it will be sufficient

* Communication No. 508 from the Kodak Research Laboratories

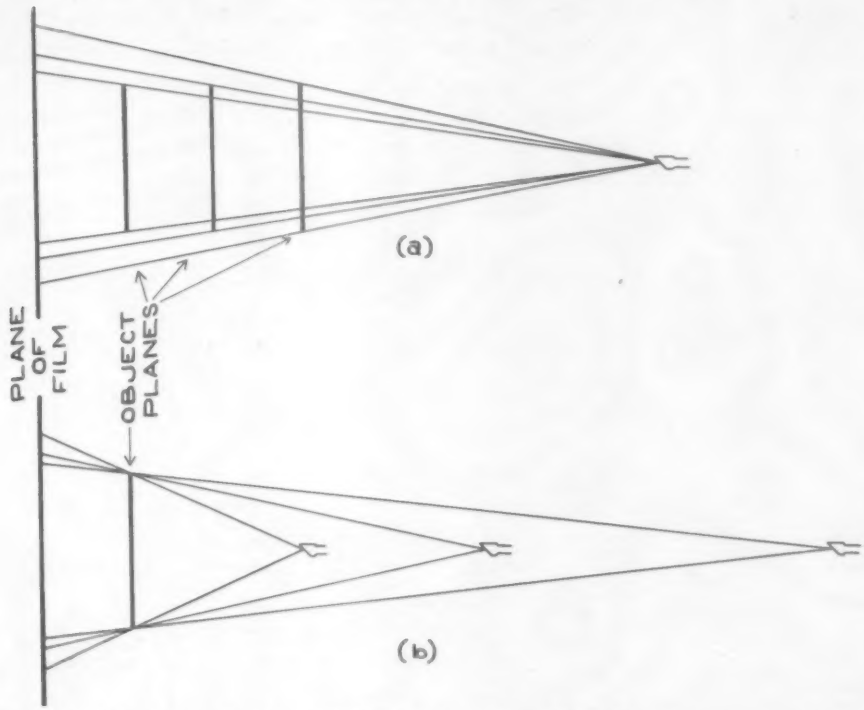

Fig. 1. Geometry of shadow projection. (*a*) Effect of varying object-film distance upon enlargement. (*b*) Effect of varying target-film distance upon enlargement.

to consider the influence of target-film distance upon distortion for two typical object-film distances, 4 and 8 inches, as shown by the curves of Figure 2.

It is obvious that with increasing target-film distance, improvement in the matter of distortion becomes progressively less, following a law of diminishing return. Most of the decrease in enlargement has occurred within the 4-foot distance; beyond this, the enlargement diminishes very slowly. On the other hand, the cost

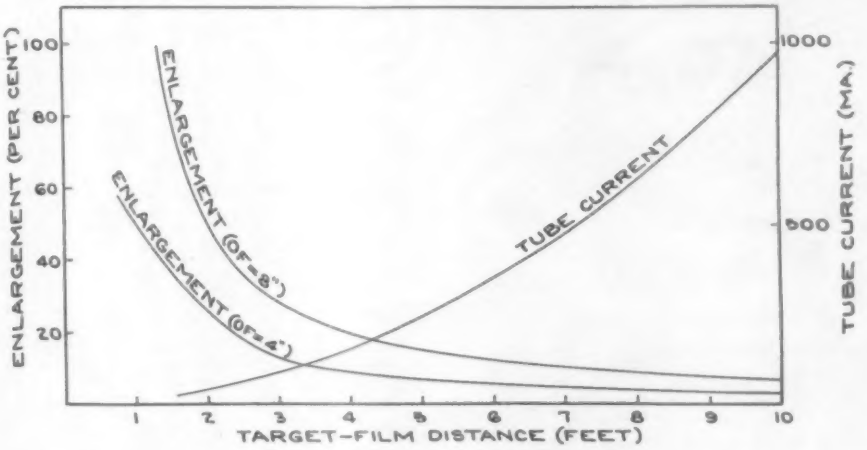

Fig. 2. Enlargement as a function of target-film distance for object-film distances of 4 and 8 inches; also tube current as a function of target-film distance (assuming tube voltage and exposure time kept constant).

of this improvement in terms of the roentgen tube current required for the exposure becomes rapidly higher, growing as the square of the target-film distance. Certainly the improvement in distortion beyond a target-film distance of 6 feet is slight, and it is questionable whether such improvement is worth the cost in greater energy of exposure. The reduction of distortion by any desired increase of target-film distance may, however, be carried out without the sacrifice of any other qualities of the roentgenogram, provided compensation for the greater exposure is made by increasing the tube current, and not by increasing tube voltage or exposure time. If the limited power of the roentgen-ray machine makes a 6-foot target-film distance impracticable, this distance may be reduced to 5 or 4 feet with but little increase in distortion.

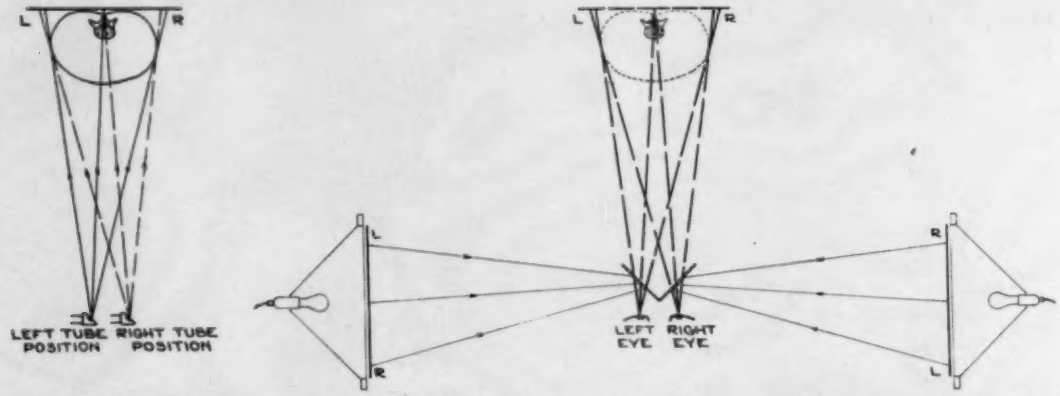

FIG. 3. To avoid distortion in the stereoscopic image, there should be exact geometric correspondence between the conditions of exposing stereoscopic films and of viewing the finished roentgenograms in the Wheatstone stereoscope. The tube shift should equal the interpupillary distance, and the eye-film distance should equal the target-film distance.

Stereoscopic roentgenograms offer another possibility of minimizing distortion. In fact, a rigorously correct stereoscopic procedure completely eliminates distortion in the stereoscopic image,[4] as is illustrated in Figure 3. In chest roentgenography at long target-film distances, however, the use of a strictly correct stereoscopic method would require that, in viewing the roentgenograms in the stereoscope, the eye-film distance be equal to the target-film distance. At a viewing distance of 4 feet or more, the eye is apt to have difficulty in seeing the finer details in the roentgenogram. Furthermore, stereoscopes are not commonly built to allow viewing distances greater than 28 or 30 inches. The problem then is to find the stereoscopic tube shift to use at a long target-film distance such as will cause minimum distortion in the stereoscopic image when the roentgenograms are viewed at a distance as short as 25 or 30 inches.

One method commonly proposed is to make the ratio of tube shift to interpupillary distance the same as the ratio of target-film distance to eye-film distance, as illustrated in Figure 4(*a*).

In this case, the eye-film distance is taken as 25 inches, the target-film distance 72 inches, and the interpupillary distance 2.5 inches. According to the above rule, tube shift/2.5 inches = 72/25, or the tube shift should be 7.2 inches. The relation between the form of the stereoscopic image and that of the original subject may readily be derived by a graphical method.[5] In Figure 4(*a*) the outline of the stereoscopic image, in dotted line, is shown for an elliptically shaped object (solid line) 8 inches thick. The distortion of a portion of the subject next the film of 4 inches thickness is also shown. It is apparent that all

parts of the image are narrower and flatter than the corresponding portions of the subject. These deviations from correct size and proportions can be diminished by the use of a slightly greater tube shift, determined by the construction shown in Figure 4(*b*). Lines from the center of the subject are drawn through the eye points, and at any chosen target-film distance, the roentgen tube shift is determined by the corresponding spacing between the two lines. This tube shift gives greater "separation" of the two stereoscopic views, as well as producing less distortion than the method shown in Figure 4(*a*).

Table 1 gives the values of stereoscopic tube shifts for various eye-film and target-film distances, as derived by the construction of Figure 4(*b*), assuming the center of the chest to be 4 inches from the film.

If the tube shift be governed by either of the constructions of Figure 4, distortion in the stereoscopic image decreases with diminishing target-film distance to the point where the latter equals the eye-film distance; in this case, distortion is eliminated completely in the stereoscopic image under the correct viewing conditions (Fig. 3).

DEFINITION OR SHARPNESS

Definition or sharpness is probably the most important physical characteristic of the roentgenographic image. For instance, if excised lungs are reinflated and roentgenographed on plain roentgen film with a fine focus tube, much more information about the finer lung structures is shown than is obtainable in the chest roentgenogram of a live patient. These fine details are due chiefly to the lack of movement, and in lesser degree to the use of a fine focus tube and the omission of intensifying screens which the immobilization makes possible. Such detail in ordinary chest

TABLE I

Target-Film Distance	Stereoscopic Tube Shift for Eye-Film Distance of		
	25 in.	28 in.	30 in.
4 ft.	5½ in.	4 5/16 in.	4¼ in.
5	6⅝	5 11/16	5⅛
6	8¼	7 1/16	6 5/16
7	9⅞	8 7/16	7 11/16
8	11	9 5/16	8 13/16

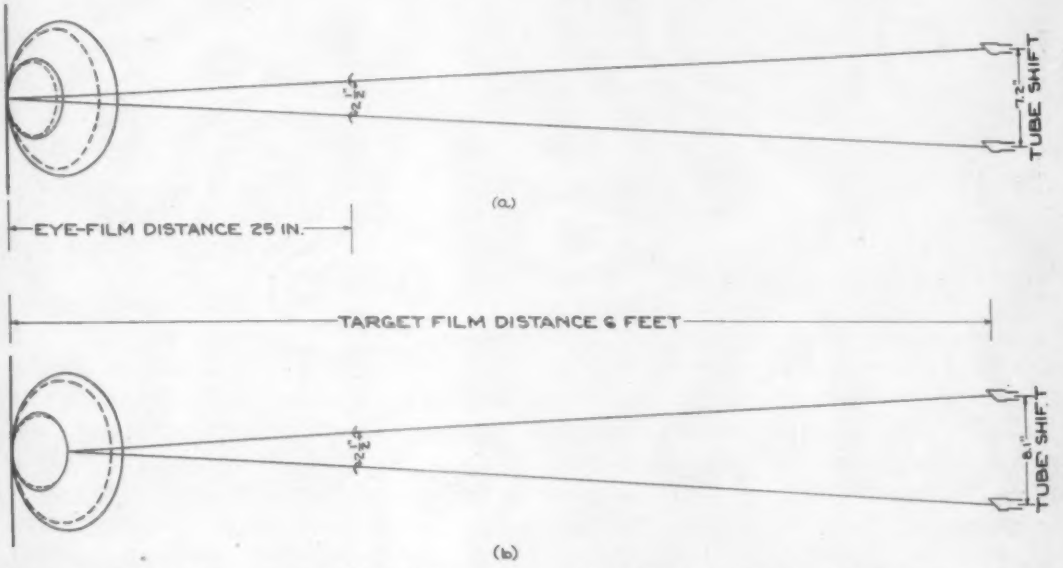

FIG. 4. Comparison of stereoscopic image (dotted line) with outline of original subject in case (*a*) the ratio of tube shift to interpupillary distance is made equal to ratio of target-film distance to eye-film distance, and (*b*) the tube shift is determined by lines drawn through eye points from center of subject.

roentgenograms would greatly enhance their diagnostic value. Of course, it is not possible to secure this same sharpness of detail in the roentgenography of the patient since movement of the lung tissues with the heart beat, the superposition of exposure times be short in order to minimize the blurring due to movement. A shorter exposure time, however, requires a greater tube current, and consequently a larger focal spot, with the result that any gain in sharpness won by shortening the

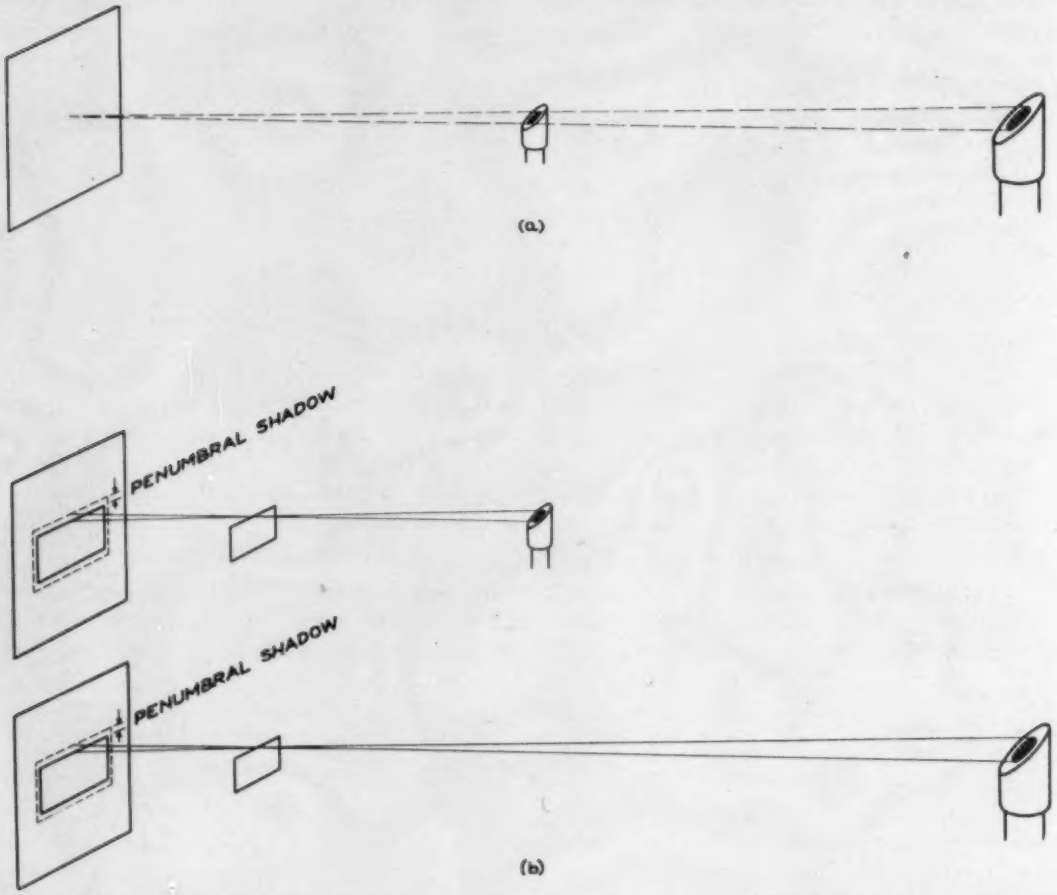

Fig. 5. (*a*) Focal spot width must be made proportional to target-film distance to allow for the necessary changes in tube current. (*b*) Under this condition, the width of the penumbral shadow is practically unaffected by target-film distance.

the roentgen-ray absorption of the chest walls, and scattered radiation, all interfere with the delineation of the finer lung details. However, the superior detail shown in the roentgenograms of excised lungs serves to illustrate the value of improved sharpness in the roentgenographic image.

The mutually conflicting requirements in chest roentgenography impose a severe burden upon the roentgen tube. The movement of the lung tissues necessitates that exposure time is counteracted more or less by the greater size of focal spot required. The increase of target-film distance to decrease distortion also necessitates a greater tube current and a larger focal spot. In any case the focal spot must be as small as possible consistent with the energy passed through it. In other words, *to secure the best definition in chest roentgenography, the focal spot must be operating at or near its maximum load capacity*. By maximum load

capacity is meant the maximum load the tube will stand consistent with a reasonable life of the tube, as specified by the manufacturer's rating. This rating increases rather gradually with decrease of exposure time.[3]

This principle governs practically the whole consideration of sharpness in chest roentgenography. It is of interest to examine the application of this principle to the effect of target-film distance upon roentgenographic sharpness. Other factors remaining the same, the energy passed through the roentgen tube must increase in proportion to the square of the target-film distance. The focal spot area must be increased approximately in proportion to the energy.[3] This means that if the angle of the target face remains constant, the diameter of the focal spot must be increased in direct proportion to the target-film distance, with the result that increasing the target-film distance has scarcely any effect upon roentgenographic sharpness. For instance, in Figure 5(*a*), one focal spot is twice as far from the film as the other; its diameter is twice, and its area four times that of the nearer focal spot. Doubling the target-film distance necessitates a 4-fold increase in tube current, which can just be accommodated by the quadrupled area of focal spot. Figure 5(*b*) shows that the width of the diffused edge of a shadow (penumbral shadow) cast by each of these focal spots is practically the same. Any advantage in sharpness of outline which would otherwise be obtained by increasing the target-film distance is almost wholly lost by reason of the larger focal spot required to carry the greater tube current.

Table II

Target-film distance (ft.)	3	4	5	6	7	8
Area of focal spot (sq. mm.)	7.1	12.6	19.7	28.3	38.5	50.2
Diameter of focal spot (mm.)	3	4	5	6	7	8
Width of penumbra (mm.)	0.86	0.80	0.77	0.75	0.74	0.73

It is possible to calculate the width of penumbra from the following relation:

$$\frac{\text{Width of penumbra}}{\text{Width of focal spot}} = \frac{\text{object-film distance}}{\text{object-target distance}}$$

which follows from the simple geometry of the case. Table II gives the results of such calculations for an object 8 inches from the film, assuming that focal spot width must increase in proportion to the target-film distance. The exposure conditions are such that a focal spot (circular) of 3 mm. diameter (as seen in the line of the central ray) is required at a target-film distance of 3 feet.

Table III

Target-film distance (ft.)	3	4	5	6	7	8
Anode slope (degrees)	30.2	23.5	19.3	16.2	14.0	12.4
Area of focal spot (sq. mm.) on target face	21.4	38.0	59.4	85.5	116.5	152
Apparent area of focal spot as projected along central ray (sq. mm.)	10.8	15.2	19.6	23.9	28.2	32.7
Apparent diameter of focal spot (mm.)	3.9	4.4	5.0	5.5	6.0	6.4
Width of penumbra (mm.)	1.11	0.88	0.77	0.69	0.62	0.59

Thus, increasing the target-film distance from 4 to 8 feet diminishes the width of diffusion at the edge of a shadow (penumbra) by 0.07 mm., an amount which would not be perceptible in the average chest roentgenogram.

In the above calculations it is assumed that the angle of the target face remains unchanged throughout. The use of the line

focus principle, however, permits the angle between the target face and the central ray to be diminished as the target-film distance is increased, and thereby makes possible a greater gain in roentgenographic sharpness. It has been pointed out by Andrus and Hambleton[2] that if the angle of the target face is made too small, there will be excessive variations in sharpness in different parts and along different directions of the roentgenogram, owing to the variations in the effective form and size of the focal spot as projected upon different portions of the film. To avoid these variations, they adopt the criterion that the maximum projection of the focal spot at the cathode edge of the film shall not be more than twice its minimum projection at the anode edge of the film (Fig. 6). With this condition governing the angle between target face and central ray, the width of the penumbra shadow cast by the central ray may be readily computed for various target-film distances. The results of such calculations are given in Table III, and apply to a 14-inch width of film, with exposure conditions assumed to require, at a 5-foot target-film distance, a focal spot (circular) of 5 mm. apparent diameter as viewed along the central ray; the object-film distance is taken as 8 inches.

Thus, by suitable application of the line focus principle, increase of target-film distance can be made to yield a slight advantage in sharpness. The gain in sharpness beyond a 6-foot distance is inappreciable and the advantage of the 6-foot over the 4-foot distance is small, amounting to 0.2 mm. in lesser width of penumbra.

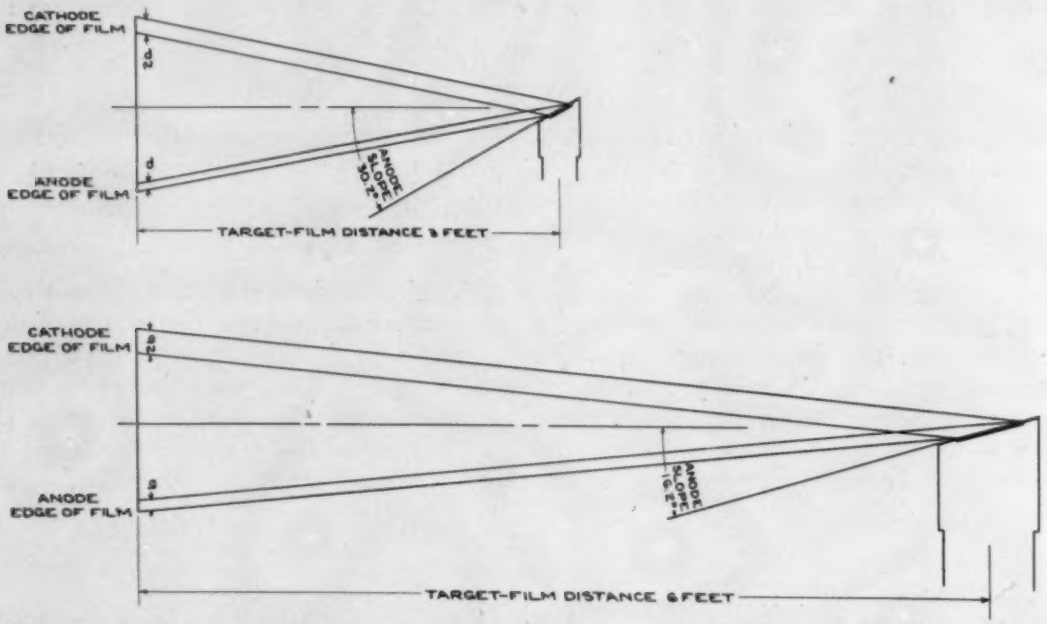

Fig. 6. To avoid excessive variations in sharpness in various portions, and along different directions, in the roentgenogram, the maximum projection of the focal spot on the cathode edge of the film should not be more than twice the minimum projection of the focal spot on the anode edge of the film (Andrus and Hambleton[2]). This criterion permits a smaller anode slope at the longer target-film distance.

Most of the lung tissue is nearer the film than the 8-inch object-film distance assumed in these calculations; penumbral shadows, therefore, will generally be smaller than those computed in Tables II and III, and the differences due to variation of target-film distance will also be less. Furthermore, in these calculations, no account has been taken of the fact that smal-

ler focal spots will stand a slightly greater load in proportion to their area than larger focal spots. In any case, it appears questionable whether any material gain in sharpness can be secured by an increase of target-film distance.

Any development which enables a smaller focal spot to carry the tube load required for a chest roentgenogram will further diminish the influence of target-film distance upon definition.

It is apparent from these considerations that target-film distance is a relatively unimportant factor in chest roentgenography. There is little to be gained either in sharpness or freedom from distortion, by the use of distances greater than 4 feet, and no appreciable gain beyond 6 feet, as long as focal spot size is made as small as possible consistent with the energy to be passed through it. On the other hand, such slight gains as are possible by an increase in target-film distance are made at a cost of greatly increased exposures and correspondingly greater requirements in the power of the roentgen machine.

SUMMARY

To give information about the structures portrayed, the important characteristics of the roentgenographic image are contrast, sharpness, and distortion.

The decrease in distortion in the single roentgenogram with increase of target-film distance follows a law of diminishing return, while the cost of such improvement in the energy required for the exposure increases rapidly, according to the square of the target-film distance. Most of the decrease in distortion occurs within a 4-foot target-film distance; beyond this, distortion diminishes very slowly. For the reduction of distortion there appear to be no appreciable advantages in target-film distances greater than 6 feet, and only a slight advantage in distances greater than 4 feet.

To minimize distortion in the stereoscopic image, a method is described for the determination of stereoscopic tube shift with long target-film distances when the roentgenograms are to be viewed in the stereoscope at a short distance (25 to 30 inches).

To secure the best definition in chest roentgenography, the roentgen tube should be operated at or near its maximum load capacity. Under this condition, variation in target-film distance has practically no effect upon sharpness, provided the angle of the target face is fixed, and has only a slight effect in case the anode slope is adjusted in accordance with the target-film distance.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Publisher: Charles C Thomas, 220 East Monroe St., Springfield, Illinois

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich. Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

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For Program of American Congress of Radiology: See this issue, page 250.

Date of Meeting: September 25–30, 1933.

Place of Meeting: Palmer House, Chicago Ill., Scientific Sessions, Scientific and Commercial Exhibits will all be held in this Hotel.

* For Officers and Standing Committees of the American Roentgen Ray Society and the American Radium Society usually carried on this page, see the April, 1933, number of the Journal.

† Combined meeting of: American Roentgen Ray Society, American Radium Society, American College of Radiology, Radiological Society of North America.

EDITORIALS

A CENTURY OF PROGRESS

CHICAGO and its spectacular, fascinating "A Century of Progress," the finest extravaganza of achievement in a century, beckons invitingly to the hundreds of radiologists who will attend the American Congress of Radiology from September 25 to 30, inclusive, at the Palmer House, Chicago.

Eighty-two miles of exhibits, hundreds of stellar attractions in the realms of science, education, history, romance, fun, foods, music, thrills and adventure comprise the Fair. Built on 424 acres of made land, stretching for three miles along the shore line of Lake Michigan, nestled almost in the shadows of the big Loop skyscrapers, "A Century of Progress" has been the world's busiest spot since the opening day. And it is the world's most colorful spot by day, and the world's brightest spot by night.

Brilliant, though softly blending—blues, reds, greens, golds, bronzes, silvers, blacks and whites—twenty-five colors in all have been employed by artists to give the grounds a blazing kaleidoscopic spectacle. At night miles of neon tubes, carefully concealed, indirect lighting, flood the great expanses of the buildings with varicolored lights. Spotlights, color fountains, mushroom ground lights all add to the glory of the sight.

Telling the story of the growth of chemistry, physics, mathematics, geology, medicine, surgery and pharmacy graphically, the hundreds of exhibits in the Hall of Science are some of the most comprehensive at the Fair. Among other things, there are sixty physics exhibits; there is a $10,000 "robot" who tells of the mechanical movements of his viscera by an illuminated "interior" view of himself; the earth sciences, appropriately epitomized by a "Giant Clock of the Ages," are shown on the screen in the center of the dial, while the minute hand ticks off two billion years of earth history.

Exhibits in jewelry, cosmetics, office furniture, the graphic arts, mineral industries and textiles are housed in the General Exhibits group; while the General Motors building has a complete assembling plant for automobiles. Long miles of exhibits in the Hall of States tell the wonders of Alaskan fisheries, of Hawaii's amazing fruits, California's beauty, Illinois' products. All in all more than thirty states present their stories in surprising detail. The United States Government Building stands in the center of the horseshoe formed by the Hall of States, and exhibits showing the strides made in the various branches of government in the last 100 years are to be found.

Illinois as host state to the nation has erected the only state building at the Fair, and its "welcome house" tells among other things the story of Lincoln through the comprehensive collection of Lincolniana to be found in three of the Host Building rooms. Stained glass windows, made by the re-discovered ancient Phoenician process, pictures colorfully Illinois scenes, history, and accomplishments. There is an auditorium where lectures are held from time to time, and the largest and most comfortable lounge in the Exposition takes up the entire south wing of the building.

Other feature attractions of the World's Fair are the exhibits of visiting nations, as Italy, Japan, China, Sweden, Czechoslovakia, Ukrania, the beautiful reproduction of a Belgian Village, and others. The Hall of Social Science telling the Story of

Man, the Radio and Communication Building, the Electrical Building, the Home Planning Group, are all particularly interesting. And so are the Mayan Temple, Chrysler Building, Horticultural Building, Hall of Religion, Firestone Building, the Sky Ride, the Dairy and Agricultural buildings, Fort Dearborn, and the Alpine gardens.

James T. Case

AMERICAN CONGRESS OF RADIOLOGY

THE Executive Council of the American Congress of Radiology, scheduled for the Palmer House, Chicago, September 25–30, inclusive, has written to as many radiologists in the United States and Canada as are listed in the headquarters' office and to many in Central and South America and abroad, inviting them to attend the Congress. All radiologists who have received the invitation are urged to send in immediately their photograph and information for the Congress album, a copy of which will be given to each member; and to send in their registration blank filled out and fee in connection, in order that they may become members of the Congress and receive free a copy of the beautiful book "Science of Radiology" which is being prepared in connection with the Congress. All arrangements are being made by the local committee, and communications may be addressed to Dr. Benjamin H. Orndoff, Chairman, 2561 N. Clark street, Chicago. Physicians and other scientists interested are invited to communicate with Dr. Orndoff.

It will be recalled that the four national radiological societies, the American College of Radiology, the American Radium Society, the American Roentgen Ray Society, and the Radiological Society of North America, are meeting jointly this year and that the most comprehensive scientific program ever given in the Americas is being prepared. Sessions will be held only until 2 p.m. each day, in order that the visiting physicians and scientists may attend the Century of Progress on the lake front. Ample accommodations for all guests will be arranged for at the Palmer House, Chicago.

James T. Case

HENRY K. PANCOAST

PRESIDENT OF THE AMERICAN CONGRESS OF RADIOLOGY, 1933

HENRY K. PANCOAST, M.D.

HENRY K. PANCOAST was born in Philadelphia, February 26, 1875. His father, Seth Pancoast, also a physician, and a graduate of the University of Pennsylvania, practiced in Philadelphia. He was, in his later years, interested in various fields outside of medicine, and his wife who was before marriage, Miss Susan George Osborn, assisted him in his work, often doing extensive translating for him in Greek, Latin and German.

Dr. Pancoast's parents both belonged to the Society of Friends and from them he has inherited the characteristics so often noticed in those of Quaker ancestry—an absolute "level headedness" and common sense which in his case are augmented by a kindliness of nature that has endeared him to his friends. He received his entire preliminary education at Friends Central School, Philadelphia, graduating at the head of his class in 1892. From his early boyhood it was definitely known that he had made up his mind to study medicine, but he had lost his parents before graduating from school, and felt it necessary to take a position for a time, before entering Medical School.

Fortunately for him, a premedical college course was not compulsory at that time and after two or three years of working in a bank (an experience that has undoubtedly been of the utmost value to him) he entered the Medical School of the University of Pennsylvania, graduating in 1898. He served as interne for two years and began to practice in the autumn of 1900. It was in May, 1902, that he was asked to take charge of the Roentgen Department of the University of Pennsylvania Hospital, succeeding Dr. Charles Lester Leonard, and the so-called "department," was at that time housed in one dark room in the basement of the Hospital. In April, 1903, Dr. Pancoast married Clara L. Boggs of Baltimore, Maryland, who has shared in every way his professional ambitions.

From 1901 to 1904, Dr. Pancoast served as Assistant Instructor in Clinical Surgery and Assistant Demonstrator in Surgery. From 1905 to 1911 he was lecturer on "Skiagraphy" and in 1912 he was appointed to the Chair of Roentgenology in the Medical School of the University of Pennsylvania. He was Secretary of the American Roentgen Ray Society in 1912, and President in 1913; Secretary of the American Radium Society 1917–1918, and President in 1919.

The Department of which Dr. Pancoast is chief has grown from its original one room to a laboratory of international reputation and has developed first, because of his own unceasing labor and unselfish devotion to his work, and secondly, because he has been singularly fortunate in his choice of associates who are young men of very exceptional ability and who share with him an untiring interest in the work. Dr. Pancoast never relaxes mentally and has had the faculty of imparting much of this same strenuous interest to his fellow workers who can never for a moment fail to realize that his work comes first in his life. He is never apart from it and even on so-called vacations, he is invariably accompanied by ponderous tomes whose aid he solicits from time to time as he plans and works on "papers" for various meetings, and when he can be persuaded to "play" it is always more or less obvious that play is considered in the light of a favor to his comrades and at the first opportunity there is sure to be a return to the work that he loves so well.

The outstanding achievements of Dr. Pancoast in the field of roentgenology thoroughly qualify him as the President of the American Congress of Radiology, the first meeting of its kind to be held in America.

C. B. P.

SOCIETY PROCEEDINGS CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa.
Annual Meeting: Chicago, Ill., Sept. 25–30, 1933.

American College of Radiology
Secretary, Dr. Albert Soiland, 1407 S. Hope St., Los Angeles, Calif.
Annual meeting: Chicago, Ill., Sept. 25–30, 1933.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio.
Annual meeting: Cleveland, Ohio, 1934.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y.
Annual meeting: Chicago, Ill., Sept. 25–30, 1933.

Radiological Section, Los Angeles County Medical Society
Secretary, Dr. R. T. Taylor, Los Angeles, Calif.
Meets on the third Wednesday of each month at the California Hospital.

Radiological Section, Southern Medical Association
Secretary, Dr. C. H. Heacock, 20 S. Dunlap St., Memphis, Tenn.
Annual meeting: Richmond, Va., November, 1933.

Brooklyn Roentgen Ray Society
Secretary, Dr. G. W. Cramp, 921 President St., Brooklyn, N. Y.
Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y.
Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. George M. Landau, 660 Groveland Park.
Meeting second Thursday of each month October to May inclusive at Virginia Hotel.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, Christian R. Holmes Hospital, Cincinnati, Ohio. Meetings held monthly.

Cleveland Radiological Society
Secretary, Dr. M. A. Thomas, Medical Arts Bldg.
Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital.
Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida Radiological Society
Secretary, Dr. W. McL. Shaw, 418 St. James Bldg., Jacksonville, Fla.
Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. L. M. Hilt, Myers Bldg., Springfield, Ill.
Regular meetings held quarterly.

Indiana Roentgen S ciety
Secretary, Dr. J. N. Collins, Indianapolis, Ind.
Annual meeting each February 22 n Indianapolis.

Michigan Association of Roentgenologists
Secretary, Dr. S. W. Donaldson, St. Joseph's Mercy Hospital, Ann Arbor, Mich. Three meetings a year, Fall, Winter, and Spring. Next meeting, Kalamazoo, Mich., October, 1933.

Milwaukee Roentgen Ray Society
Secretary, Dr. J. E. Habbe, 221 Wisconsin Ave., Milwaukee, Wis.
Meets first Friday in October, December, February and April. Place of meeting designated by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

New England Roentgen Ray Society
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass.
Meets monthly on third Friday, Boston Medical Library.

New York Roentgen Society
Secretary, Dr. C. W. Schwartz, 33 E. 68th St., New York.
Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N.C.
Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. H. S. Bull, 604 Masonic Temple, Auburn, N. Y.
Three meetings a year—January, May and November.

Pennsylvania Radiological Society
Secretary, Dr. W. E. Reiley, Clearfield, Penna.

Philadelphia Roentgen Ray Society
Secretary, Dr. Karl Kornblum, 3400 Spruce St.
Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. W. W. Fray, Strong Memorial Hospital.
Meets monthly on second Thursday from October, 1932, to May, 1933 inclusive, at 7:45 at the Rochester Medical Association Building.

St. Louis Roentgen Club
Secretary, Dr. W. K. Mueller, University Club Bldg.
Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston, S. C.
Meets at time and place of South Carolina State Medical Association.

Texas Radiological Society
Secretary-Treasurer, Dr. C. P. Harris, Houston, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Roentgen Ray Society
Secretary, Dr. C. C. Taylor, University Hospital, Ann Arbor, Mich.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Meets first and third Wednesday evening of the month from October to June, at 8 o'clock in the amphitheatre of the University Hospital.

Virginia Roentgen Ray Club
Secretary, Dr. Wright Clarkson, 205 S. Sycamore St., Petersburg, Va.
Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Luis Fariñas, Animas 110, Havana, Cuba.
Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1., or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Indian Radiological Association
Secretary, Sd. Subodh Mitra, 148 Russa Rd., Calcutta.
Meets annually in January, and at such places and times as the Council may appoint.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Allies, 134, Louvain, (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summer time.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11/52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April in different German cities, at least once in five years in Berlin. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Maracine 30 Bucarest, Rumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR, in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society.
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowksi, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summer time.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summer time.

Society of Medical Radiology of Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. H. Scheuermann, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institue of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Society of Roentgenology
Meets first Tuesday each month, October to July.

Orient

Japan X-ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike, Kyoto, Japan. Meets bi-monthly on third Sunday.

SCIENTIFIC PROGRAM OF THE AMERICAN CONGRESS OF RADIOLOGY

September 25 to 30, 1933, Inclusive

Palmer House, Chicago, Illinois

Arranged by the Scientific Program Committee

GEORGE E. PFAHLER, M.D., *Chairman*, Philadelphia, Pa.
WILLIAM H. CAMERON, M.D., New York City
DONALD S. CHILDS, M.D., Syracuse, N.Y.
EDWIN C. ERNST, M.D., St. Louis, Mo.
BYRON H. JACKSON, M.D., Scranton, Pa.
BURTON J. LEE, M.D., New York City
JOHN T. MURPHY, M.D., Toledo, Ohio
EUGENE P. PENDERGRASS, M.D., Philadelphia, Pa.
ROLLIN H. STEVENS, M.D., Detroit, Mich.

September 25, 1933
GRAND BALL ROOM MONDAY, 9:00 A.M.

GENERAL MEETING*

Call to order and presentation of first five Speakers: BENJAMIN H. ORNDOFF, M.D., Chairman of the Executive Council.
Address of Welcome: AUSTIN A. HAYDEN, M. D., President of the Chicago Medical Society.
Address: RUFUS C. DAWES, President of A CENTURY OF PROGRESS Exposition.
Address: HUGH S. CUMMING, M.D., D.Sc., Surgeon General, U.S. Public Health Service.
Address: MORRIS FISHBEIN, M.D., Editor, *Journal of American Medical Association.*

Intermission—15 Minutes

Address: HENRY K. PANCOAST, M.D., President, American Congress of Radiology, Professor of Radiology, University of Pennsylvania.
Address: FRANKLIN H. MARTIN, M.D., Director General, American College of Surgeons.
Address: "*Radiosensitivity of Tumor Tissue*," JAMES EWING, A.M., M.D., Sc.D., Professor of Pathology, Cornell University; Pathologist to Memorial Hospital.
Induction of JOHN T. MURPHY, M.D., President-Elect, by William A. Evans, M.D., President American Roentgen Ray Society.
Induction of W. HERBERT MCGUFFIN, M.D., President-Elect, by Byron H. Jackson, M.D., President Radiological Society of North America.
Induction of ROLLIN H. STEVENS, M.D., President-Elect, by Burton J. Lee, M.D., President American Radium Society.
Induction of HENRY K. PANCOAST, M.D., President-Elect, by Albert Soiland, M.D., President American College of Radiology.
Brief Report of Committees and Special Announcements. (Note—Following the opening meeting, the special committee meetings of the various component Radiological Societies will be announced by the officers of the Societies, and may take place sometime after adjournment each day.)

2:00 P.M. Adjournment

* At this meeting, there will be a general photograph made, and each will be numbered. It is requested that each person present write the name and address on the card found on the chair, which will be collected immediately.

September 26, 1933
GRAND BALL ROOM TUESDAY, 9:00 A.M.

Section "A"

CHEST DISEASES

Presiding Officer, Dr. John T. Murphy, President, American Roentgen Ray Society

9:00—"*The Roentgen Ray in the Study of Pathology of Pulmonary Tuberculosis*," KENNON DUNHAM, M.D., Cincinnati, Ohio. Associate Professor of Medical Department; Director of Tuberculosis, University of Cincinnati.

9:20—"*Correlation of Clinical and Roentgenological Observation in Pulmonary Tuberculosis*," LAWRASON BROWN, M. D., Saranac Lake, N.Y. Consultant to the Trudeau Sanatorium.
HOMER L. SAMPSON, Roentgenologist to the Trudeau Sanatorium.

9:40—"*Tuberculosis in Children*" F. MAURICE MCPHEDRAN, M.D., Philadelphia, Pa. Assistant Professor of Medicine, Henry Phipps Institute.

10:00—"*The Roentgen Examination of the Heart: A Critical Study of the Frontal Silhouette*" FRED J. HODGES, M.D., Ann Arbor, Mich. Professor of Roentgenology, University of Michigan.
CARLETON B. PEIRCE, M.S., M.D., Assistant Professor of Roentgenology —University of Michigan.

10:20—"*Serial Bronchography in the Early Diagnosis of Bronchial Carcinoma*," Pedro L. Farinas, M.D., Havana, Cuba. Chief of the X-ray Department, National Hospital.

10:40—"*Where is the Diaphragm?*" William H. Stewart, M.D., New York City. Visiting Physician, Roentgen Department, Lenox Hill and Lutheran Hospitals.

11:00 A.M. Recess

11:20—"*Lymphoblastoma of the Chest and Elsewhere*" George W. Holmes, M.D., Boston, Mass. Clinical Professor of Roentgenology, Harvard Medical School, Roentgenologist, Massachusetts General Hospital.

11:40—"*Roentgen Diagnosis of Interlobar Pleurisy*" (Lantern Slides) Charles A. Waters, M.D., Baltimore, Md. Associate in Roentgenology, Johns Hopkins Hospital.

12:00—"*Accessory Sinus Diseases in Relation to Chest Diseases*," W. Walter Wasson, A.B., M.D., Denver, Colo. Attending Radiologist, Children's Hospital and St. Anthony Hospital.
Harold D. Waltz, M.D., Fellow in Radiology, Child Research Council.

12:20—"*Non-Tuberculous Inflammation of the Lungs*," W. Warner Watkins, M.D., Phoenix, Arizona. Director, Pathological Laboratory; Radiologist, St. Joseph's Hospital and St. Luke's Home for Tuberculosis.

12:40—"*Surgical Condition within the Chest, Under Roentgen Observations*" William A. Evans, M.D., Detroit, Michigan. President, American Roentgen Ray Society.

1:00—"*Practical Suggestion on the Use of Iodized Oil in Bronchography*" LeRoy Sante, M.D., St. Louis, Missouri. Professor of Radiology, St. Louis Medical School. Chief Radiologist, St. Louis City Hospital; Radiologist, St. Mary's Hospital Group.

1:20—"*Scattered X-rays in Chest Roengenography*," R. B. Wilsey, M.A., Rochester, New York. Physicist, Kodak Research Laboratories.

1:30—"*Bronchiectiasis from the Roentgenologist's Standpoint*" Fred H. Clark, M.D., Aspinwall, Pa. Roentgenologist, U. S. Veterans Bureau Hospital.

1:40—"*A Roentgenological Technique for the Determination of the Efficiency of Pulmonary Ventilation: Relations of Linear and Area Measurements of the Lung Field to Clinical Determinations of Pulmonary Capacity*," Walter Fray, M.S., M.D., Rochester, N.Y. Assistant Professor of Medicine (Radiology); Assistant Radiologist—Strong Memorial Hospital.

2:00 P.M. Adjournment

September 26, 1933

Red Lacquer Room Tuesday, 9:00 A.M.

Section "B"

PHYSICS, BIOLOGY, AND THERAPEUTICS

Presiding Officer, Dr. Rollin H. Stevens, President, American Radium Society

9:00—"*The Genealogy of the X-ray*," A. W. Crane, M.D., Kalamazoo, Michigan.

9:20—"*Data Concerning Three Years Experience with 600 kv. (Peak) Roentgen Therapy*," Seeley G. Mudd, B.S., M.D., Pasadena, California. Research Associate in Radiology, California Institute of Technology.
Clyde K. Emery, B.A., M.D., Research Fellow in Radiology, California Institute of Technology.
Orville M. Meland, M.D.
William E. Costolow, M.D.

9:40—"*Some Practical Applications of the Recent Advances in Physics*," W. D. Coolidge, Ph.D., Schenectady, N.Y. Director of Research, General Electric Company.
E. E. Charlton, Ph.D., Research Engineer—General Electric Company.

10:00—"*Energy Considerations in Medium and High Voltage Therapy*," Charles C. Lauritsen, Ph.D., Pasadena, California. Associate Professor of Physics, California Institute of Technology.

10:20—"*Application of Physical Measurements in Clinical Irradiation*," Lauriston S. Taylor, Washington, D.C. Associate Physicist, Head, X-Ray Laboratory, National Bureau of Standards.

10:40—"*Training for Radium Therapy*," WM. H. CAMERON, M.D., New York City. Secretary—American Radium Society; Instructor Radium Therapy, Dermatological Department, New York University and Bellevue Hospital Medical College.

11:00 A.M. RECESS

11:20—"*Physical and Biological Characteristics of 700 kv. X-Rays*," G. FAILLA, D.Sc., New York City. Physicist, Memorial Hospital.

11:45—"*Distribution of X-rays within the Human Body*," EDITH H. QUIMBY, M.A., New York City. Associate Physicist, Memorial Hospital.
MURRAY M. COPELAND, M.D., Clinical Fellow in Cancer Research, Memorial Hospital.
R. C. WOODS.

12:05—"*The Measurement of Gamma Rays in Roentgens*," G. FAILLA, D.Sc., New York City. Physicist, Memorial Hospital.
L. MARINELLI, B.Sc.

12:20—"*Heublein's Method of Continuous Irradiation of the Entire Body in the Treatment of Generalized Neoplasms*," LLOYD F. CRAVER, M.D., New York City. Attending Physician, Memorial Hospital.
WILLIAM S. MACCOMB, M.D.

12:40—"*The Problems of Protection and Their Solution in Short Wave Therapy*," T. LEUCUTIA, M.D., Detroit, Michigan. Associate Roentgenologist, Harper Hospital.
K. E. CORRIGAN, Ph.D., Physicist, Harper Hospital.

1:00—"*Preliminary Study of the Effect of Artificial Fever Upon Hopeless Tumor Cases*," STAFFORD L. WARREN, M.D., Rochester, N. Y. Associate Professor of Medicine; Radiologist, Strong Memorial Hospital.

1:20—"*Studies on Composite X-ray Filters*," A. MUTSCHELLER, Ph.D., Long Island City, N.Y. Instructor and Consulting Physicist, Columbia University Post-Graduate Medical School; Director of Research, Westinghouse X-Ray Laboratories.

1:40—"*An Apparatus for the Production of Very High Voltage X-Rays*," D. M. SLOAN, Berkeley, California. Whiting Fellow in Physics, University of California.
J. J. LIVINGOOD, Research Associate of Department of Physics, University of California.
FRANK M. EXNER, Physicist, Institute Cancer Research, Columbia University.

2:00 P.M. ADJOURNMENT

September 27, 1933

GRAND BALL ROOM WEDNESDAY, 9:00 A.M.

Section "A"

GASTROINTESTINAL DISEASES

Presiding Officer, Dr. H. HERBERT MCGUFFIN, President, Radiological Society of North America

9:00—"*Duodenitis and its Roentgenologic Characteristics*," B. R. KIRKLIN, B.S., M.D., Rochester, Minnesota. Associate Professor of Radiology, University of Minnesota (Mayo Foundation); Head of Section on Roentgenology and Director of Division of Radiation, Mayo Clinic.

9:20—"*Roentgenology of Duodenal Ulcer. (a) The Behavior of the Stomach and Duodenum. (b) Methods of Obtaining Outline Deformity in Roentgenograms*," HOLLIS E. POTTER, M.D., Chicago, Illinois. President, Chicago Roentgen Society.

9:40—"*Duodenal Diverticulosis—A Report of Thirty-Six Cases*," JOHN D. LAWSON, M.D., Sacramento, California.

10:00—"*The Redundant Duodenum*," A Roentgenologic Study (8 Lantern Slides), MAURICE FELDMAN, M.D., Baltimore, Maryland. Assistant Professor of Gastroenterology, University of Maryland; Associate Roentgenologist, Sinai Hospital.

10:20—"*An Analysis of 1000 Consecutive Examinations of the Stomach and Duodenum from the Clinical, Roentgenological, and Surgical Viewpoint; with Particular Reference to the Incidence, Diagnosis, and Treatment of Ulcer and Carcinoma of the Stomach*," NELSON M. PERCY, M.D., Chicago, Illinois. Professor of Surgery, University of Illinois College of Medicine; Surgeon-in-Chief, Augustana Hospital.

David S. Beilin, M.D., Radiologist, Augustana Hospital.

10:40—"*Functional Disturbances of the Colon in Relation to the Roentgen Diagnosis of Organic Colonic Disease*," James T. Case, M.D., D.M.R.E., Professor of Radiology, Northwestern University Medical School; Attending Staff, Passavant, Grant and Evanston Hospitals; Editor, *Annals of Roentgenology*.

11:00 A.M. Recess

11:20—"*The Small Intestines: Correlation of Anatomic, Pathologic, and Roentgenologic Findings*," Lewis Gregory Cole, M.D., New York City.

11:40—"*An Evaluation of a New Procedure in the Study of the Small Intestine*," Eugene P. Pendergrass, M.D., Philadelphia, Pa. Assistant Professor of Radiology, University of Pennsylvania. W. Osler Abbott, M.D., Instructor in Medicine and Assistant Instructor in Pharmacology—University of Pennsylvania.

12:00—"*Cholecystography with Tetraiodophenolphthalein by Mouth; Experience with Regard to Success and Untoward Reactions*" and "*Physiology of the Gall Bladder: Cholecystography Shows no Psychic Emptyings*," R. R. Newell, M.D., San Francisco, California. Professor of Medicine, Stanford University School of Medicine.
Edward Leef, M.D., Instructor in Medicine, Stanford University School of Medicine.

12:20—"*Roentgen Diagnosis of Diseases of the Colon: An Evaluation of Methods*" Harry M. Weber, B.S., M.D., Rochester, Minnesota. Instructor in Radiology, University of Minnesota (Mayo Foundation), Associate in Section on Roentgenology, Mayo Clinic.

12:40—"*Roentgenologic Studies of Amoebic Colitis*," J. J. Vallerno, M.D., Panama, R. P.

1:00—"*Dangers of Fluoroscopy and Methods of Protection Against Them*," E. T. Leddy, M.D., Rochester, Minnesota

1:20—"*Colon Studies. VII. Variations in the Fixation of the Ceco-Colon: Their Clinical Significance*," John L. Kantor, M.D., New York City. Associate in Medicine, Columbia University; Attending Physician, Gastro-Intestinal Diseases, Vanderbilt Clinic; Gastroenterologist and Associate Roentgenologist, Montefiore Hospital.
Samuel Schechter, M.D., Assistant Attending Roentgenologist, Metropolitan Hospital.

1:40—"*Viscerocardiac Reflexes*," Lester Levyn, M.D., Buffalo, New York.
Werner J. Rose, M.D.

2:00 P.M. Adjournment

September 27, 1933

Red Lacquer Room Wednesday, 9:00 A.M.

Section "B"

CANCER OF THE MOUTH, SKIN AND MISCELLANEOUS

Presiding Officer, Dr. John T. Murphy, President, American Roentgen Ray Society

9:00—"*Irridation Treatment of Cancer of the Lip and Mouth, Technique and Results*," Charles L. Martin, E.E., M.D., Dallas, Texas. Professor of Radiology, Baylor University Medical School; Director, Baylor Tumor Clinic; Radiologist, Baylor Hospital.

9:20—"*The Roentgen-Ray and Radium Treatment of Cancer of the Lip*," Bernard P. Widmann, M.D., Philadelphia, Pa. Assistant Professor of Radiology, Post Graduate School of Medicine, University of Pennsylvania, Chief Radiologist, Philadelphia General Hospital.

9:40—"*Management of Cancer of the Mouth and the Cervical Lymphatics*," Douglas Quick, M.D., New York City.

10:00—"*Protracted Irradiation in the Treatment of Neoplasms of the Mouth and Pharynx—A Comparison between X-Rays, Five Gram Pack and Small Radium Pack*," Radiation Therapy Service, New York City. Bellevue Hospital, Division of Cancer, Department of Hospitals.
Ira Kaplan, B.Sc., M.D., Visiting Radiation Therapist, Clinical Professor of Surgery, New York University, Bellevue Hospital Medical College.
Rieva Rosh, M.D., Radiation Therapist.
Milton Friedman, M.D., Assistant Radiation Therapist.

CARL B. BRAESTRUP, B.Sc., P.E., Physicist.

10:20—"*The Treatment of Carcinoma of the Pharynx, Tonsil and Extrinsic Larynx by Divided Doses of Roentgen Therapy*," HAYES E. MARTIN, M.D., New York City. Assistant Attending Surgeon, Memorial Hospital.
ROBERT F. MCNATTIN, M.D., Fellow in Clinical Research, Memorial Hospital.

10:40—"*Roentgen Therapy of Epithelioma of the Pharynx and Larynx*," MAURICE LENZ, M.D., New York City. Associate Radiotherapist, Presbyterian Hospital; Attending Radiotherapist, Montefiore Hospital.
CORNELIUS G. COAKLEY, M.A., M.D., Professor of Oto-Laryngology, Columbia University, College of Physicians and Surgeons.
ARTHUR PURDY STOUT, M.D., Associate Professor of Surgery, Columbia University; Attending Surgical Pathologist, Presbyterian Hospital.

11:00 A.M. RECESS

11:20—"*The General and Medical History of Electricity Told With Old Books Taken from My Library*," LEO PARISEAU, M.D., Montreal, Quebec.

11:40—"*Radiology and the Radiologist*," EDWARD H. SKINNER, M.D., Kansas City, Missouri. Chief, Department of Radiology, St. Luke's Hospital.

12:00—"*Three years of 300 kv. Cancer Therapy*," J. ERNEST GENDREAU, M.D., Montreal, Quebec.

12:20—"*Cancer of the Skin*," GEORGE W. GRIER, M.D., Pittsburgh, Pa. Associate Professor of Roentgenology, University of Pittsburgh; Roentgenologist, Presbyterian Hospital; Passavant Hospital; St. John's Hospital; Elizabeth Steel Magee Hospital; Pittsburgh Diagnostic Clinic; Falk Clinic.

12:40—"*Results of Irradiation in Diseases of the Skin*," JOSEPH JORDAN ELLER, M.D., New York City.

1:00—"*A Review of Angiomas (Birth Marks) Treated During the Last Fifteen Years, With Analysis of End Results*," WILLIAM S. NEWCOMET, M.D., Philadelphia, Pa. Radium Therapeutist, Jefferson Hospital; Radiologist, Presbyterian, Oncologic and Rush Hospitals.

1:20—"*The Malignant Diseases of the Thyroia Gland*," URSUS V. PORTMANN, M.D., Cleveland, Ohio. Director, Department of Radiation Therapy, Cleveland Clinic Foundation.

1:40—

2:00 P.M. ADJOURNMENT

September 27, 1933

GRAND BALL ROOM WEDNESDAY, 8:30 P.M.

Convocation of the newly elected Fellows of the American College of Radiology conducted by the officers:

President.....HENRY K. PANCOAST, M.D.
Vice President.W. WALTER WASSON, M.D.
Treasurer.....HENRY SCHMITZ, M.D.
Historian.....CHARLES G. SUTHERLAND, M.D.
Executive Secretary
.....BENJAMIN G. ORNDOFF, M.D.

Brief Address by the President, HENRY K. PANCOAST, M.D.

Caldwell Lecture—"*The Diagnosis and Treatment of Carcinoma of the Lung*," EVARTS A. GRAHAM, M.D., St. Louis, Missouri, Professor of Surgery, Washington University Medical School; Surgeon-in-Chief, Barnes and St. Louis Children's Hospital.

Conducted by the Officers of the American Roentgen Ray Society:

President....JOHN T. MURPHY, M.D.
First Vice President
.....SHERWOOD MOORE, M.D.
Second Vice President
.....ROBERT DRANE, M.D.
Secretary...EUGENE P. PENDERGRASS, M.D.
Treasurer...EDWARD L. JENKINSON, M.D.

September 28, 1933

GRAND BALL ROOM THURSDAY, 9:00 A.M.

Section "A"

DISEASES OF BONES, JOINTS AND BONE TUMORS

Presiding Officer, Dr. ROLLIN H. STEVENS, President, American Radium Society

9:00—"*Seventy Cases of Five-Year Cures in Sarcoma of Bone*," (Lantern Slides), CHARLES F. GESCHICKTER, M.D., Baltimore, Maryland. Surgical Pathologi-

cal Laboratory, Johns Hopkins Hospital.

9:20—"*Changes in the Lower Extremity Bones in Association with Arteriovascular Disease*," Maurice M. Pomeranz, M.D., New York City. Radiologist, Hospital for Joint Diseases.
Henry L. Jaffe, M.D., Pathologist, Hospital for Joint Diseases.

9:40—"*Injuries of the Spine, Both Acute and Chronic*," Howard P. Doub, M.D., Detroit, Michigan. Roentgenologist—Henry Ford Hospital.

10:00—"*Parathyroid Disease*," Lawrence Reynolds, M.D., Detroit, Michigan. Assistant Roentgenologist, Harper Hospital; Roentgenologist, Children's Hospital of Michigan.
E. R. Witwer, M. D., Assistant Roentgenologist, Harper Hospital and Children's Hospital of Michigan.

10:20—"*Osteomalacic Diseases in Monkeys and Man, a Metabolic and Roentgenographic Study*," Ralph S. Bromer, M.D., Philadelphia, Pa.
E. P. Corson-White, M.D. (By invitation) Irvin Stein, M.D. (By Invitation).

10:40—"*X-Ray Evidences of Necrosis of the Head of the Femur Following Intracapsular Fractures of the Neck*," D. B. Phemister, M.D., Chicago, Illinois. Department of Surgery—University of Chicago.

11:00 A.M. RECESS

11:20—"*Infectious Granulomata of the Bones and Joints with Special Reference to Coccidioidal Disease*," Ray A. Carter, M.A., M.D., Los Angeles, California. Roentgenologist, Los Angeles County General Hospital; Associate Professor, Roentgenology, Medical Department, University of Southern California.

11:40—"*Motion Picture Showing Reduction of Fractures and the Removal of Foreign Bodies, Using Oil-Immersed Shock-Proof Units, Bi-Plane Fluoroscopic Control and Special Fracture Device*," Lex G. McCutchen, M.D., St. Louis, Missouri. Radiologist, Firmin Desloge Hospital and St. Louis County Hospital.

12:00—"*Further Observations on Spontaneous Multiple Symmetrical Fractures*," L. A. Milkman, M.D., Scranton, Pennsylvania. Director of X-Ray Department Scranton State Hospital. Director X-Ray Department, Mercy Hospital; Professor Physics, St. Thomas College.

12:20—"*Pelligrini-Stieda's Disease, Post-Traumatic Calcification of the Collateral Tibial Ligament of the Knee*," Max Ritvo, M.D., Boston, Massachusetts. Roentgenologist, Boston City Hospital. Roentgenologist, Boston Bikur Cholim Hospital. Assistant Professor of Roentgenology, Tuft's Medical School. Instructor in Roentgenology, Harvard Medical School.

12:40—"*Lead Poisoning in Infants and Children, with Special Reference to the Roentgenological Findings*," Edward C. Vogt, M.D. Instructor in Roentgenology, Harvard Medical School; Roentgenologist, Infant's and Children's Hospital.
Charles F. McKhann, M.D. Assistant Professor of Pediatrics, Harvard Medical School; Associate Physician, Infant's and Children's Hospital.

1:00—"*Experimental and Clinical Studies of Pulmonary Abscess and Gangrene Following Tonsillectomy*," Isadore Pilot, M.D., Chicago, Illinois. Associate Professor of Medicine and Pathology, University of Illinois College of Medicine.

1:20—

1:40—

2:00 P.M. ADJOURNMENT

September 28, 1933

RED LACQUER ROOM THURSDAY, 9:00 A.M.

Section "B"

BREAST DISEASES

Presiding Officer, Dr. W. Herbert McGuffin, President, Radiological Society of North America

9:00—"*Further Observations in Roentgen Diagnosis of the Breast*," Ira H. Lockwood, M.D., Kansas City, Missouri.

9:20—"*Combined Surface and Interstitial Radiation in the Treatment of Mammary Cancer*," Albert Soiland, M.D., Los Angeles, California. Chairman, Malignancy Board of the California Hospital.

9:40—"*A Method of Irradiating the Axilla with Special Reference to Mammary*

Cancer," JAMES J. DUFFY, M.D., New York City. Assistant Attending Surgeon, Memorial Hospital.
CHARLES DE FOREST LUCAS, M.D., Clinical Research Fellow, Memorial Hospital.

10:00—"*The Relative Value of Surgery, Radium and X-Ray Therapy in Carcinoma of the Breast*," ISAAC LEVIN, M.D., New York City. Clinical Professor of Cancer Research, New York University.

10:20—"*A Series of Carcinomas of the Breast Treated by Irradiation Alone Covering a Five Year Period*," FRANK E. ADAIR, M.D., New York City.

10:40—"*An Analysis of a Group of Primary Carcinomas of the Lungs, Treated with Deep X-Ray Therapy*," WILLIS F. MANGES, M.D., Sc.D., Philadelphia, Pa. Professor of Roentgenology, Jefferson Medical College.

11:00 A.M. RECESS

11:20—"*Technique and Results of Irradiation in Carcinoma of the Breast*," GEORGE E. PFAHLER, M.D., Philadelphia, Pa. Professor of Radiology, Graduate School of Medicine, University of Pennsylvania.
JACOB H. VASTINE, M.D., Clinical Professor of Radiology, Woman's Medical College.

11:40—"*The Treatment of Chest Wall Secondaries in Breast Carcinoma—A Preliminary Report of a New Radium Technique*," GORDON E. RICHARDS, M.D., Toronto, Ontario. Associate Professor of Radiology, University of Toronto; Director, Ontario Government Institute of Radiotherapy; Director, Department of Radiology, Toronto General Hospital.

12:00—"*The Treatment of 'Bleeding Nipple' by Means of Interstitial Radiation*," MAX CUTLER, M.D., Chicago, Illinois. Director, Tumor Clinic, Michael Reese Hospital.

12:20—"*Depth Doses of Roentgen Radiation, Striking at Angles Other Than Ninety Degrees, Measured in a Water Phantom*," ERNST A. MAY, M.D., Newark, New Jersey. Director, Metcalf Foundation for Radiotherapy, Orange Memorial Hospital, Orange, New Jersey.

12:40—"*Histopathology of Irradiated Hodgkin's Disease and Lymphoblastoma*," ALEXANDER BRUNSCHWIG, M.D., Chicago, Illinois. Department of Surgery and Division of Radiology, University of Chicago.

1:00—
1:20—
1:40—

2:00 P.M. ADJOURNMENT

September 29, 1933
GRAND BALL ROOM FRIDAY, 9:00 A.M.

Section "A"
UROLOGY, GYNECOLOGY AND MISCELLANEOUS

Presiding Officer, Dr. JOHN T. MURPHY, President, American Roentgen Ray Society

9:00—"*Studies with Opaque Media in Urology*," LEOPOLD JACHES, M.D., New York City. Radiologist, Mt. Sinai Hospital.
MOSES SWICK, B.S., M.D. Adjunct Surgeon, Mount Sinai Hospital; Attending Urologist, Harlem Hospital.

9:20—"*Opaque Studies of the Uterus and Pelvis*," DON CARLOS HEUSER, M.D., Buenos Aires, Argentine.

9:40—"*Renal Peristalsis During Pyelonephrities: A Roentgenophysiologic Study*," HANS A. JARRE, M.D., Detroit, Michigan. Attending Roentgenologist, Grace Hospital; Roentgenologist, Woman's Hospital and North End Clinic.
R. E. CUMMING, M.D.

10:00—"*Further Observations in the Diagnosis of Tumos of the Kidney*," BERNARD H. NICHOLS, M.D., Cleveland, Ohio. Director of Roentgenology, Cleveland Clinic.

10:20—"*Roentgen Examination of the Chests of Five Hundred Newborn with Reference to Pathology Present Other Than Enlarged Thymus*," LEON SOLIS-COHEN, M.D., Philadelphia, Pa. Radiologist, Jewish Hospital; Radiologist, Memorial Hospital.
SAMUEL BRUCK, M.D. Roentgenologist, Northern Liberties Hospital and Northeastern Hospital; Associate Roentgenologist, Jewish Hospital.

10:40—"*A Radiological and Clinical Study of the Female Symphysis Pubis*," JOHN M. BARNES, M.D., Buffalo, New York.

Roentgenologist, Millard Fillmore Hospital.

11:00 A.M. Recess

11:20—"*The Fate of Thorium Dioxide in the Body After Intravenous Injection*," Ernst A. Pohle, M.D., Ph.D., Madison, Wisconsin. Professor of Radiology, University of Wisconsin.
Gorton Ritchie, M.D. Assistant Professor of Radiology, University of Wisconsin.

11:40—"*Animal Experiment with Colloidal Thorium, a Study in Lymphatic Absorption*," (Lantern Slide Demonstration). R. Pomeranz, M.D., Newark, N. J. Associate Radiologist, Newark Beth Israel Hospital.

12:00—"*Roentgen Studies on the Fate of Calcium in the Bones of Retained Dead Fetuses*," An Evaluation of "Decalcification" as a Roentgenographic Diagnostic Criterion of Death of the Fetus in Utero. Paul C. Hodges, Ph.D., M.D., Chicago, Illinois. Professor of Roentgenology, University of Chicago.
John W. Lawlah, M.S., M.D. Assistant Roentgenologist, Provident Hospital.

12:40—"*Is the Antiquity of a Cell a Factor in Determining the Resistance to Radiation, and can we Imply Stimulating Doses of Radiation in Cancer Therapy?*" Robert H. Milwee, M.D., Dallas, Texas. Roentgenologist, The Dallas Methodist Hospital; Bradford Memorial Hospital for Children; Presbyterian Clinic; Radiation Therapist, City of Dallas Parkland Hospital.

12:20"*Methods of Standardization of Roentgenographic Technique*," Charles Weyl, Philadelphia. Professor, Moore School of Electrical Engineering, Univ. of Pennsylvania.

1:00—"*The Use of the Roentgen Rays in Science and Industry*," C. A. Poole, Covington, Kentucky. Director of Industrial Research, Kelley-Koett Mfg. Co., Inc.

1:20—"*An Accurate Simple Method of Densitometric Analysis of Roentgenograms*," Harold C. Hodge, M.D., Rochester, New York.
Stafford L. Warren, M.D.

1:40—

2:00 P.M. Adjournment

September 29, 1933

Red Lacquer Room Friday, 9:00 A.M.

Section "B"

UROLOGY AND GYNECOLOGY, AND ABDOMINAL DISEASES

Presiding Officer, Dr. Rollin H. Stevens, President, American Radium Society

9:00—"*The Radiation Treatment of Carcinoma of the Bladder*," Benjamin S. Barringer, M.D., New York City. Attending Surgeon, Memorial Hospital; Attending Urologist, Fifth Avenue Hospital.

9:20—"*Cancer of the Bladder—Methods of Treatment*," Curtis F. Burnam, M.D., Baltimore, Maryland. Associate Professor of Surgery, Johns Hopkins Hospital; Radiologist, The Howard A. Kelly Hospital.

9:40—"*Irradiation and Electrothermic Surgery in the Management of Carcinomata of the Urinary Bladder*," J. Thompson Stevens, M.D., Montclair, N. J. Director, Department for Study and Treatment of Neoplastic Diseases, Montclair Community Hospital, and St. Josph's Hospital, Paterson, N. J.

10:00—"*Radiation Treatment of Carcinoma of the Uterus*," Henry L. Schmitz, A.M., M.D., LL.D., Chicago, Illinois. Professor and Head of Department of Gynecology, Loyola University School of Medicine; Director, Mercy Hospital Institute of Radiation Therapy.

10:20—"*The Treatment of Uterine Fibromas*," Leda J. Stacy, M.D., Rochester, Minnesota.

10:40—"*Radiation Treatment of Carcinoma of the Cervix*," William P. Healy, M.D., New York City. Attending Surgeon, Department of Gynecology, Memorial Hospital.

11:00 A.M. Recess

11:20—"*Technic of Treatment of Cancer of Cervix with Radon*," Frank E. Simpson, M.D., Chicago, Illinois. Director of the Radium Clinic, American Hospital.

11:40—"*Studies in the Diagnosis and Treatment of Teratoma Testis*," Russell S. Ferguson, M.D., New York City. Assistant Surgeon, Memorial Hospital; Assistant in Clinical Surgery, Cornell University Medical College; Assistant Surgeon, New York Hospital.

12:00—"*A Critical Study of the Use of the Lead Perforator and Reciprocal in Radiation Therapy*," F. LIBERSON, M.D., New York City. Roentgenologist, U. S. Public Health Service Hospitals.

12:20—"*Radium Treatment of Primary Carcinoma of the Rectum*," HARRY H. BOWING, M.D., Rochester, Minnesota. Head of Section on Therapeutic Radiology (Radium)—Mayo Clinic; Assistant Professor of Radiology, Mayo Foundation for Medical Education and Research, Graduate School, University of Minnesota.

ROBERT E. FRICKE, M.D., Associate in Section on Therapeutic Radiology (Radium), Mayo Clinic; Instructor of Radiology, Mayo Foundation for Medical Education and Research, Graduate School, University of Minnesota.

12:40—"*Abdominal Hodgkin's Disease*," EDWARD L. JENKINSON, M.D., Chicago, Illinois. Director, Roentgen Department, St. Luke's Hospital and St. Joseph's Hosp.; Associate Professor, Roentgenology, Northwestern Medical College.

ARTHUR R. ELLIOTT, M.D., Clinical Professor of Medicine, Rush Medical College; Senior Attending Staff Medicine, St. Luke's Hospital.

1:00—"*Palliative Irradiation of Carcinoma of the Stomach*," GEORGE T. PACK, M.D., New York City.

1:20—"*Postoperative Radiation in Carcinoma of the Ovary: Study of Twenty-Two Patients*," (To be read by Title), JOHN T. FARRELL, JR., M.D., Philadelphia, Pa. Assistant Roentgenologist.

JOHN B. MONTGOMERY, M.D., Assistant in Gynecology, Jefferson Hospital.

1:40—"*Some New Principles Regarding the Design of X-Ray Apparatus*," ALBERT BOUWERS, M.D., Eindhoven, Holland.

2:00 P.M. ADJOURNMENT

September 29, 1933

GRAND BALL ROOM FRIDAY, 8:30 P.M.

Presentation of Medals and Honors by the Officers of the Radiological Society of North America:

President...W. HERBERT MCGUFFIN, M.D.
First Vice President
.....WILLIAM E. CHAMBERLAIN, M.D.
Second Vice President
.....W. WARNER WATKINS, M.D.
Third Vice President
.....HAROLD A. SPILMAN, M.D.
Secretary-Treasurer
.....DONALD S. CHILDS, M.D.

The Janeway Lecture—JAMES EWING, M.D., New York City, Professor of Pathology, Cornell University; Pathologist to Memorial Hospital.

Conducted by the Officers of the American Radium Society:

President.....ROLLIN H. STEVENS, M.D.
First Vice President
.....GEORGE W. GRIER, M.D.
Second Vice President
.....HOWARD MARROW, M.D.
Secretary.....WM. H. CAMERON, M.D.
Treasurer.....ZOE A. JOHNSTON, M.D.

September 30, 1933

GRAND BALL ROOM SATURDAY, 9:00 A.M.

Section "A"

NEUROLOGY AND MISCELLANEOUS

9:00—"*Pituitary Tumors: Radiological Aspects of Diagnosis and Treatment*," MERRILL C. SOSMAN, M.D., Boston, Massachusetts. Assistant Professor of Roentgenology, Harvard Medical School; Roentgenologist, Peter Bent Brigham Hospital; Associate in Roentgenology, Children's Hospital.

9:20—"*Encephalography*," KARL KORNBLUM, M.D., Philadelphia, Pa. Associate in Radiology, University of Pennsylvania. FRANCIS C. GRANT, M.D., Assistant Professor of Neuro-Surgery, School of Medicine, University of Pennsylvania; Associate in Surgery, School of Medicine, University of Pennsylvania; Associate in Neuro-Surgery, Graduate School of Medicine, University of Pennsylvania.

9:40—"*Recent Advances in Encephalography*," CORNELIUS G. DYKE, M.D., New York City. Assistant Director of X-Ray Department, Neurological Institute.

10:00—"*Spinal Cord Lesions and Their Recognition by Roentgenologic Methods*," JOHN D. CAMP, S.B., Ch.B., M.D., Rochester, Minnesota. Assistant Pro-

fessor of Radiology, University of Minnesota (Mayo Foundation); Associate in Section on Roentgenology, Mayo Clinic.

10:20—"*The Normal Appearance of the Ventricles of the Brain, and the Displacements Caused by Temporal Lobe Tumors*," A. H. Pirie, M.D., Montreal, Quebec. Royal Victoria Hospital.

10:40—"*Roentgenological Considerations of Sinus Diagnosis With and Without Radiopaque Oils*," Edwin C. Ernst, M.D., St. Louis, Missouri.

11:00 A.M. Recess

11:20—"*The Diagnosis of Accessory Sinuses*," Amedee Granger, M.D., New Orleans, La. Professor of Radiology, Louisiana University Medical Center; Director of Department of Radiology, Charity Hospital.

11:40—"*Roentgen Examination of the Mastoid Processes*," Frederick M. Law, M.D., New York City.

12:00—"*The Scope and Technique of Soft Tissue Roentgenography*," John R. Carty, M.D., New York City. Radiologist-in-Chief, New York Hospital; Associate Professor of Radiology, New York Hospital, Cornell Medical College Association.

12:20—"*The Roentgenological Diagnosis of Intracardiac Calcifications*," Paul A. Bishop, M.D., Philadelphia, Pa. Director, Department of Radiology, Pennsylvania Hospital.
Hugo Roesler, M.D., Associate Professor of Medicine and Roentgenology, Temple University.

12:40—(*Title to be Sent In*), Manuel F. Madrazo, M.D., Mexico City, Mexico. Roentgenologist, National R. R. of Mexico and Spanish Welfare Association; Executive Officer, Federal Health Department.

1:00—(*Title to be Sent In*), Filiberto Rivero, M.D., Havana, Cuba. Head Professor of Radiology and Physiotherapy, Havana University; Director, Department of X-Ray and Physiotherapy, Mercedes Hospital; Vice Director, Juan Bruno Zayas, Department for Study and Treatment of Cancer.

1:20—"*Further Observations on the Treatment of Pituitary Tumors*," Edgar W. Spackman, M.D., Philadelphia, Pa. Instructor in Radiology, Graduate School of Medicine, University of Pennsylvania.

1:40—"*General Closing Session by the Officers of the Congress.*"

2:00 P.M. Adjournment

September 30, 1933

Red Lacquer Room Saturday, 9:00 A.M.

Section "B"

MISCELLANEOUS

Presiding Officer, Dr. John T. Murphy, President, American Roentgen Ray Society

9:00—"*Experimental Studies of Portions of the Lymphatic System by Means of the Roentgen Ray*," Leon J. Menville, M.D., New Orleans, Louisiana. Assistant Professor, Medicine and Radiology, Tulane University of Louisiana School of Medicine.
J. N. Ane, M.D., Instructor in Medicine and Radiology, Tulane University of Louisiana School of Medicine.

9:20—"*Pernicious Leucopenia*," W. Edward Chamberlain, M.D., Philadelphia, Pa. Professor of Radiology, Temple University Medical School.

9:40—"*Diagnosis and Roentgen Treatment of Parathyroid Dysfunction*," Edwin A. Merritt, M.D., Washington, D. C.
Edgar M. McPeak, M.D.

10:00—"*Radium in the Treatment of Hyperthyroidism*," Roland E. Loucks, M.D., Detroit, Michigan.

10:20—"*Roentgen Treatment of Hyperthyroidism*," Thomas A. Groover, M.D., D.Sc., Washington, D. C.
Arthur Carlisle Christie, M.S., M.D.

10:40—"*Tuberculosis of the Larynx and Neck*," (Lantern Slides), Henry K. Taylor, M.D., New York City. Roentgenologist, Sea View Hospital.
Louis Nathanson, M.D., Assistant Roentgenologist, Sea View Hospital.

11:00 A.M. Recess

11:20—"*A Report of 62 Cases of Herpes Zoster Treated with X-Rays*," John M. Keichline, M.D., Huntingdon, Pa. Radiologist, J. C. Blair Memorial Hospital.

11:40—"*Primary New Growths Involving the*

Hand," Bernard F. Schreiner, M.D., Buffalo, New York. William H. Wehr, M.D.

12:00—"*Some Phases in the Management of Myelogenous Leukemia*," Kenneth D. A. Allen, M.D., Denver, Colorado; Roentgenologist, Presbyterian, Children's and Denver General Hospitals.

12:20—"*Radiotherapy in Urticaria*," (To be read by Representative), Humberto H. Carelli, M.D., Buenos Aires, Argentine.

12:40—"*A Classification of Tumors from the Standpoint of Radiosensitiveness*," A. U. Desjardins, M.D., Rochester, Minnesota. Director, Division of Radiology, Mayo Clinic; Assistant Professor of Radiology, University of Minnesota.

1:00—"*A Method to Render Radioresistant Tumors Radiosensitive*," M. J. Sittenfield, M.D., New York City.

1:20—

1:40—*General Closing Session by the Officers of the Congress*

2:00 P.M. ADJOURNMENT

Note—The effort will be made to carry out this program in the order arranged but circumstances may demand re-arrangement at the last moment.

Note—In order to carry out this program, it is essential that each speaker be limited to use not over twenty minutes which may include reading, remarks, and lantern slide demonstrations.

PROTECTION OF RADIOLOGY AS A SPECIALTY OF MEDICINE

To the Editor:

I am inclosing some information regarding the Pacific Roentgen Club which I hope you can publish in the *American Journal of Roentgenology and Radium Therapy*. I am also inclosing excerpt from resolutions of the Commonwealth Club.

Henry Snure

* * * * *

(1) At the April 25, 1933, meeting of the Commonwealth (San Francisco) Club of California the following matter was taken up: "The Public Health Section recommends that the Commonwealth Club endorse and support the following principles and program as the most satisfactory approach to improved health organization in California.

I. .....

II. Recognition of the fact that medical service is composed of two distinct factors: (a) The personal, professional service of the physician and surgeon. (b) The ancillary forms of medical service such as hospitalization, nursing, laboratory procedures and x-ray.

III. .....

IV. That, since the expenses involving in the ancillary forms of health service are the more unpredictable and constitute the heavier burden, the insurance principle should be applied first to this type of service. This limitation of the insurance plan is recommended in order that it may be given a fair trial without being imperiled by the difficulties which might arise if, in the beginning, it were applied to the entire complex system of medical service.

V. That, since it is of fundamental importance that the physician be able to obtain all information necessary to diagnosis and since he is often unable to obtain this information because of the patient's inability to meet the expense involved in the performance of complete tests, *that various city, county and state health departments extend their activities to make available to the public at not to exceed cost, the ancillary forms of medical service of a preventive and diagnostic character*."

These points were argued pro and con but no definite action was taken at the meeting in question.

* * * * *

California roentgenologists have banded themselves together to stand firmly upon their rights as practitioners of medicine. Aroused over the constant inroads upon their profession by laymen, nurses, corporations, and others not licensed in the healing art, the Californians have decided that the time is here for united protection and an aggressive offense against exploitation of their profession.

The organization is founded upon the principle that radiology is the practice of medicine and as such is due the full recognition of a learned and dignified branch of the profession. Threats of state medicine and an imminent move on the part of some powerful groups in California to ask that the state, counties and municipalities furn-

ish x-ray service at cost, led representatives of the profession to gather at Santa Maria on June 11 to form the Pacific Roentgen Club. Problems affecting Radiology in its relationship with other branches of medicine and with the general field of public health were thoroughly discussed at the session. Lowell S. Goin, M.D., of Los Angeles was named chairman of the club; L. H. Garland, M.D., of San Francisco, secretary, and these two, with Henry Snure, M.D., of Los Angeles, John Lawson, M.D., of Sacramento, and Robert Stone, M.D., of the University of California, form the executive committee. Roentgenologists considering a position on the West Coast are invited to communicate with the Pacific Roentgen Club. Any information that will help prevent exploitation or other unfair treatment will be cheerfully given.

"There have been constant inroads upon Radiology by laymen, nurses, corporations and others not scientifically trained in this highly important branch of medical practice," said a statement issued from the meeting. "We as Radiologists object to this for several reasons. First from the standpoint of public health. The X-ray is a potentially dangerous instrument, as is the scalpel of the surgeon, the hypodermic of morphia and the anesthetic. It is because these are in skillful and careful hands that they are of benefit to humanity—a thing equally true of the roentgen rays. The danger is not only one of physical damage to tissue (negligible in skilled hands), but the less spectacular and more commonly encountered danger resident in the absurd diagnoses by incompetent persons.

"We maintain that Radiology, being as it is, the diagnosis and treatment of human disease, is the practice of medicine, and as such, should be solely in the hands of those licensed to practice the healing art.

"We object to the exploitation of any physician for the gain of any non-medical concern. Under ruling of the California courts a corporation cannot engage in the practice of medicine. Nevertheless corporations do practice Radiology, which we maintain to be a part of the practice of medicine.

"X-ray diagnosis is one of the greatest advances that has been achieved in the practice of medicine. Radiation therapy combined with good surgery offers the only chance we know of today for the cure of malignant disease. If Radiology is degraded by falling into the hands of lay people and is forced down to the state where the Radiologist is merely the servant of a corporation, the high standards we have set up will fall and not only medicine but the general public will suffer a distinct loss.

"It is to prevent these things, and to stand firmly upon our rights as practitioners of medicine that we have organized. We propose to take such steps as may be necessary to prevent further inroads upon Radiology. We intend to maintain and improve our present standards and to have at all times the recognition due us as a learned and dignified branch of medicine. The California Medical Association has recognized this officially in Resolution No. 5 of the House of Delegates, adopted at the recent annual meeting and printed on page 465 of the June issue of *California and Western Medicine*."

The organization is being rapidly perfected and a program is now being mapped out to carry through the principles upon which it is founded.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., 105 Rutledge Ave., Charleston, S. C.

TECHNIQUE OF ROENTGEN EXAMINATION OF THE TEMPOROMANDIBULAR ARTICULATION

By JOHN SPROULL, M.D.
HAVERHILL, MASSACHUSETTS

FROM personal communication with many roentgenologists and roentgen technicians, I am convinced that but few possess a simple satisfactory technique for roentgen examination of the temporomandibular joint. No claim is made to priority for the method presented in this communication. Its development was brought about because of the difficulties and uncertainties encountered in the application of some other recommended methods.

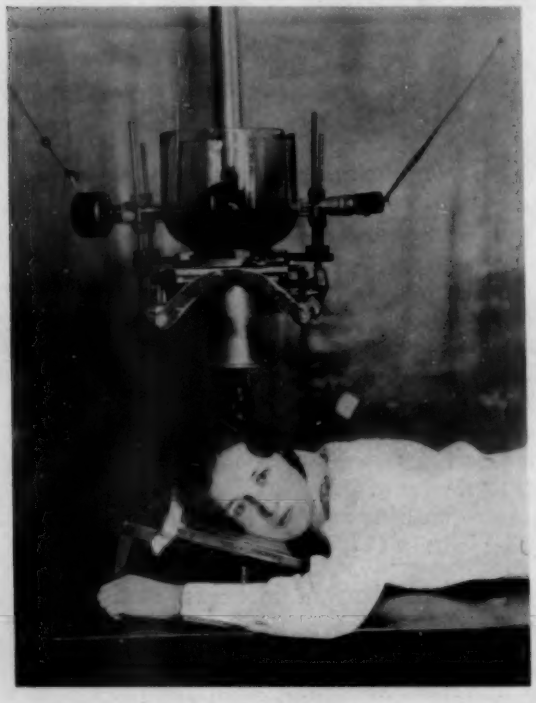

Fig. 1. Lateral view showing 23° angle sinus board, position of patient and the point of centering the tube.

TECHNIQUE

Position of the Patient. The patient may lie either on the abdomen or the side to be examined. The cassette is placed on a 23° angle sinus board and the lateral aspect of the head corresponding to the joint to be examined is placed in a true lateral position on the cassette.

Position of the Tube. The tube is centered at a point 3 inches toward the vertex from the tragus which is uppermost; that is, if the right side is being examined, the

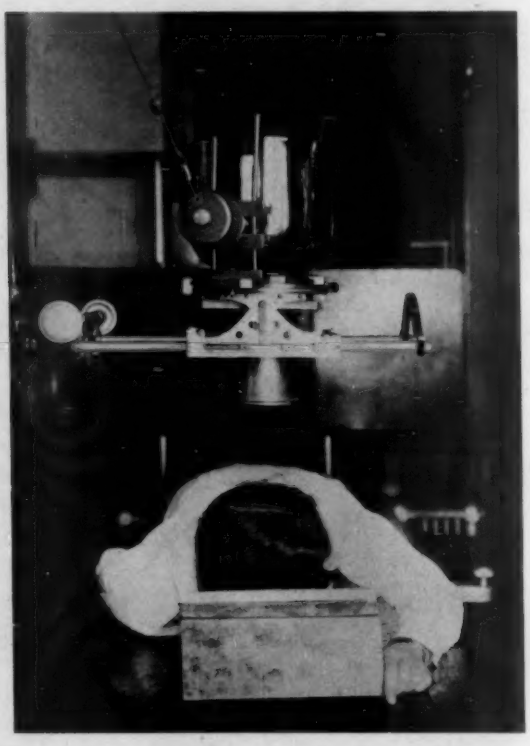

Fig. 2. Position of patient and tube seen in longitudinal direction.

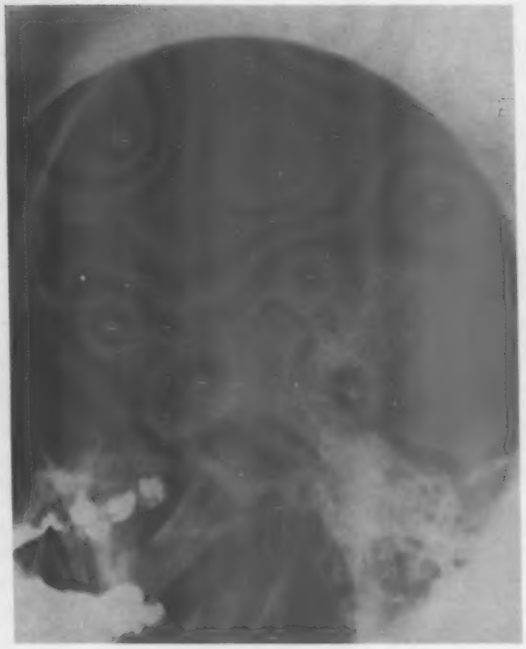

FIG. 3. View of temporomandibular articulation with mouth closed. Note the clear outline of the mandibular fossa and condyle. The joint space is well visualized.

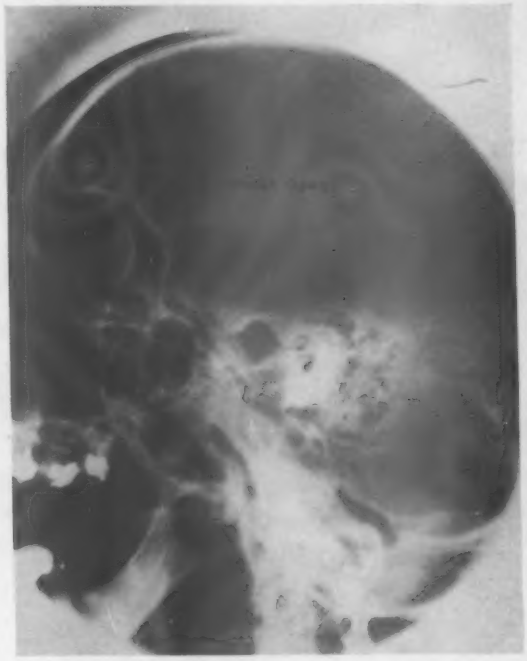

FIG. 4. View with mouth open. Note the clear visualization of the mandibular fossa, the eminentia articularis, and the articular surface of the condyle. Contrast with Figure 3 shows the range of normal mobility.

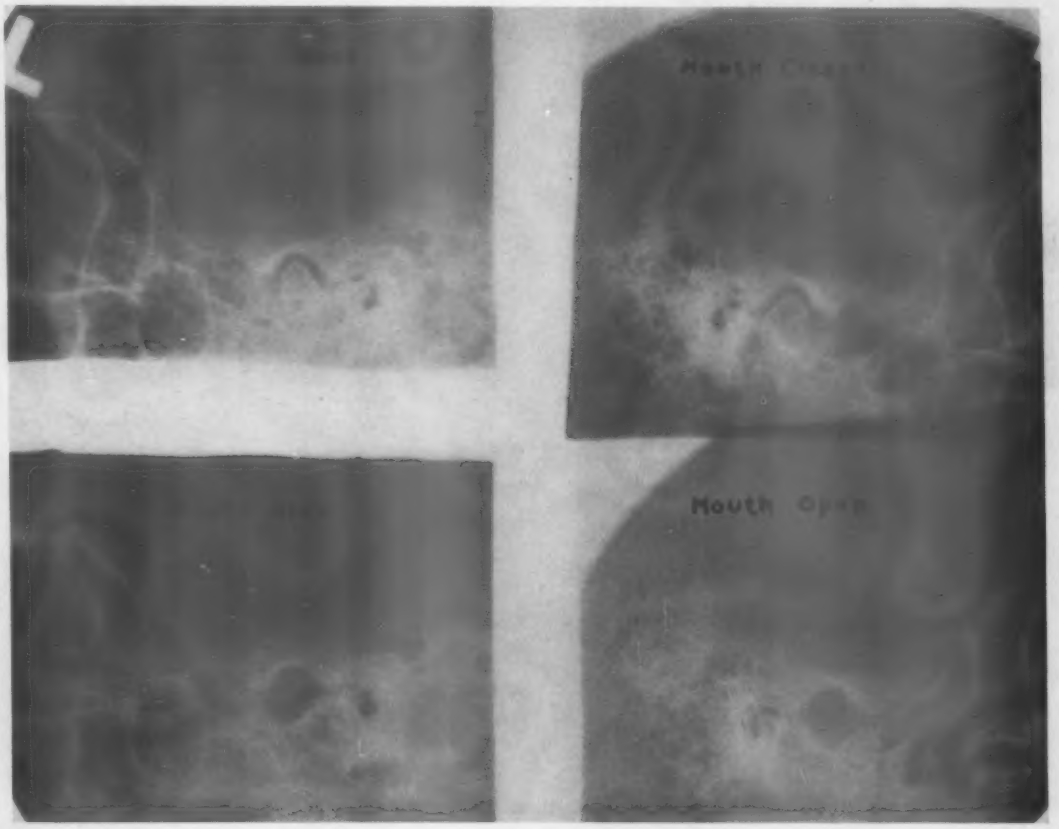

FIG. 5. Right and left mandibular joints of one patient taken with mouth open and closed; permits the comparison of one joint with the other.

tube is centered toward the vertex from the left tragus which is the uppermost in this position. No angulation of the tube is necessary (Figs. 1 and 2).

Two exposures should be made, one with the mouth closed and one with the mouth open. This procedure is recommended (Figs. 3 and 4). If desired, four exposures may be made on an 8″ × 10″ film. This permits the comparison of the appearances and mobility of one joint with the other (Fig. 5).

The method is simple and requires no great exercise of memory, and is satisfactory in that an excellent view is afforded of the width of the joint space, and details of the margins of the mandibular fossa and of the condyle of the mandible are clearly visualized. In addition, the method permits an estimate of the mobility of the articulation when alternate exposures are made with the mouth closed and open.

Vol. XXX, No. 2

A NOMOGRAM AS AN AID IN THE DETERMINATION OF THE CUMULATIVE DOSE IN ROENTGEN AND RADIUM THERAPY*

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BUFFALO, NEW YORK

WHEN radiation treatments are being carried on by means of roentgen rays or radium packs, it has been found expedient, both for the welfare of the patient and for the better effect on the tumor itself, to divide the treatments over a period of several days or weeks. It becomes essential, therefore, to know the cumulative dose at any time during the course of treatment, so that the radiation may be discontinued when the tolerance limit of the skin is reached. It is of even greater importance

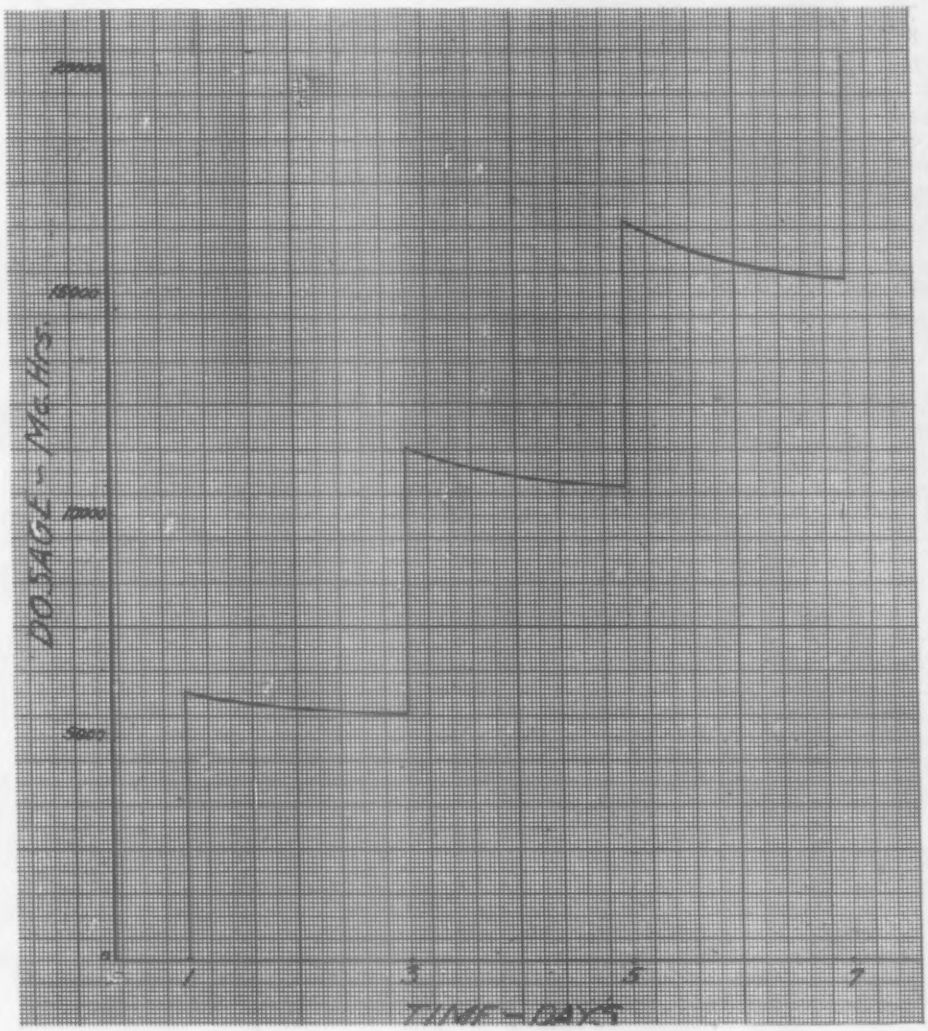

FIG. 1. Accumulation of radiation effect when 6,000 milligram-hours are given every second day.

* From the State Institute for the Study of Malignant Diseases, Buffalo, N. Y. (Burton T. Simpson, M.D., Director).

TABLE I

CUMULATIVE DOSAGE TABLES

TREATMENTS EVERY DAY

Daily Increment	3000	4000	5000	6000	8000	10000	15000
Days	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.
1	3000	4000	5000	6000	8000	10000	15000
2	5880	7842	9800	11760	15685	19608	29410
3	8655	11540	14415	17320	23060	28840	43270
4	11320	15070	18850	22640	30150	37700	56560
5	13880	18480	23110	27760	36960	46200	69320
6	16340	21750	27210	32680	43500	54400	81600
7	18700	24900	31140	37400	49800	62250	93400
8	20970	27420	34920	41950	55850	69800	104720
9	23150	30820	38550	46300	61680	76850	115600
10	25220	33620	42020	50500	67250	83950	126100
11	27250	36300	45400	54500	72610	90600	136100
12	29200	38890	48600	58380	77800	97000	145800
13	31050	41370	51680	62050	82750	103150	155000
14	32930	43730	54640	65650	87500	109100	163900
15	34600	46020	57500	69100	92030	114800	172400
16	36240	48220	60200	72400	96410	120300	180600
17	37800	50320	62800	75590	100620	125500	188500
18	39310	52320	65320	78600	104700	130500	196000
19	40790	54250	67720	81580	108500	135400	203300
20	42200	56150	70000	84400	112200	140000	210000

TREATMENTS EVERY SECOND DAY

Daily Increment	3000	4000	5000	6000	8000	10000	15000
Days	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.
1	3000	4000	5000	6000	8000	10000	15000
3	5770	7690	9615	11540	15380	19231	28850
5	8325	11100	13880	16650	22200	27750	41620
7	10680	14250	17810	21360	28500	35600	53400
9	12860	17150	21450	25700	34300	42870	64300
11	14870	19830	24800	29710	39670	49550	74350
13	16740	22300	27900	33420	44600	55720	83600
15	18450	24590	30750	36850	49180	61400	92150
17	20040	26690	33380	40000	53380	66650	100000
19	21500	28610	35800	42900	57200	71500	107310
21	22840	30410	38050	45600	60800	76000	114200
23	24080	32090	40100	48100	64150	80150	120500
25	25210	33600	42000	50400	67200	83960	126200
27	26290	35000	43800	52500	70000	87460	131500
29	27260	36300	45410	54050	72617	90700	136400
31	28160	37500	46900	55900	75000	93700	140900

TABLE I (*Continued*)

TREATMENTS EVERY THIRD DAY

Daily Increment	3000	4000	5000	6000	8000	10000	15000
Days	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.
1	3000	4000	5000	6000	8000	10000	15000
4	5660	7548	9435	11320	15100	18869	28300
7	8020	10700	13370	16040	21380	26800	40100
10	10118	13499	16850	20230	26950	33750	50570
13	11970	15970	19950	23950	31900	39930	59850
16	13620	18170	22700	27250	36300	45400	68200
19	15080	20120	25120	30180	40200	50250	75500
22	16380	21850	27300	32770	43650	54600	82000
25	17520	23380	29200	35070	46700	58400	87750
28	18540	24730	30900	37100	49420	61800	92800
31	19450	25930	32400	38900	51850	64900	97300
34	20250	27000	33730	40500	54000	67590	101300
37	20960	27950	34920	41920	55900	69940	104840
40	21570	28800	35970	43200	57600	72000	108200
43	22120	29550	36900	44300	59060	73840	111000

TREATMENTS EVERY FOURTH DAY

Daily Increment	3000	4000	5000	6000	8000	10000	15000
Days	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.
1	3000	4000	5000	6000	8000	10000	15000
5	5550	7409	9260	11115	14817	18521	27780
9	7730	10315	12890	15480	20620	25780	38680
13	9585	12790	15980	19200	25580	31950	47980
17	11170	14900	18620	22370	29790	37220	55850
21	12520	16700	20870	25070	33380	41720	62600
25	13660	18230	22780	27380	36430	45550	68380
29	14650	19540	24410	29320	39050	48800	73220
33	15480	20650	25800	31000	41270	51580	77410
37	16190	21600	27000	32420	43150	53910	81000
41	16800	22400	28000	33650	44750	55940	84000
45	17310	23090	28870	34700	46120	57660	86600
49	17750	23670	29600	35600	47300	59300	88800
53	18130	24170	30220	39500	48300	60550	90650

TREATMENTS EVERY FIFTH DAY

Daily Increment	3000	4000	5000	6000	8000	10000	15000
Days	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.	mg-hr.
1	3000	4000	5000	6000	8000	10000	15000
6	5456	7277	9093	10915	14550	18187	27280
11	7462	9960	12445	14940	19920	24890	37320
16	9110	12160	15190	18240	24310	30370	45550
21	10455	13960	17440	20940	27910	34870	52300
26	11560	15440	19270	23150	30850	38530	57800
31	12470	16650	20770	24960	33250	41550	62300
36	13210	17640	22000	26430	35220	44000	66000
41	13820	18450	23020	27670	36850	46030	69520
46	14320	19120	23860	28650	38170	47700	72270
51	14810	19660	24530	29460	39250	49070	74200
56	15130	20110	25100	30120	40150	50180	75800
61	15390	20480	25560	30680	40890	51080	77100

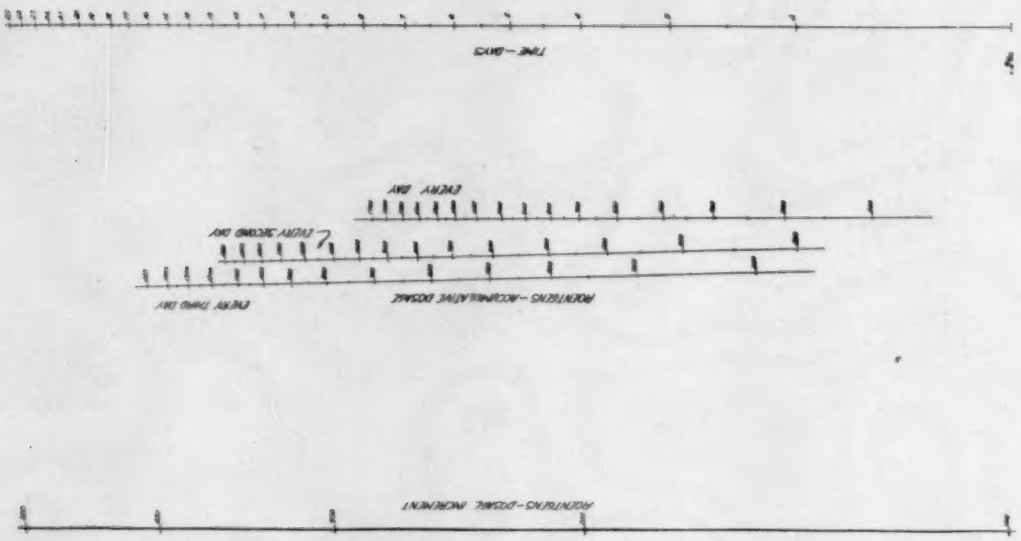

FIG. 3. Nomogram used in determining the cumulative dose from roentgen rays (λ effective 0.16 Å). This dosage is for air scattering only.

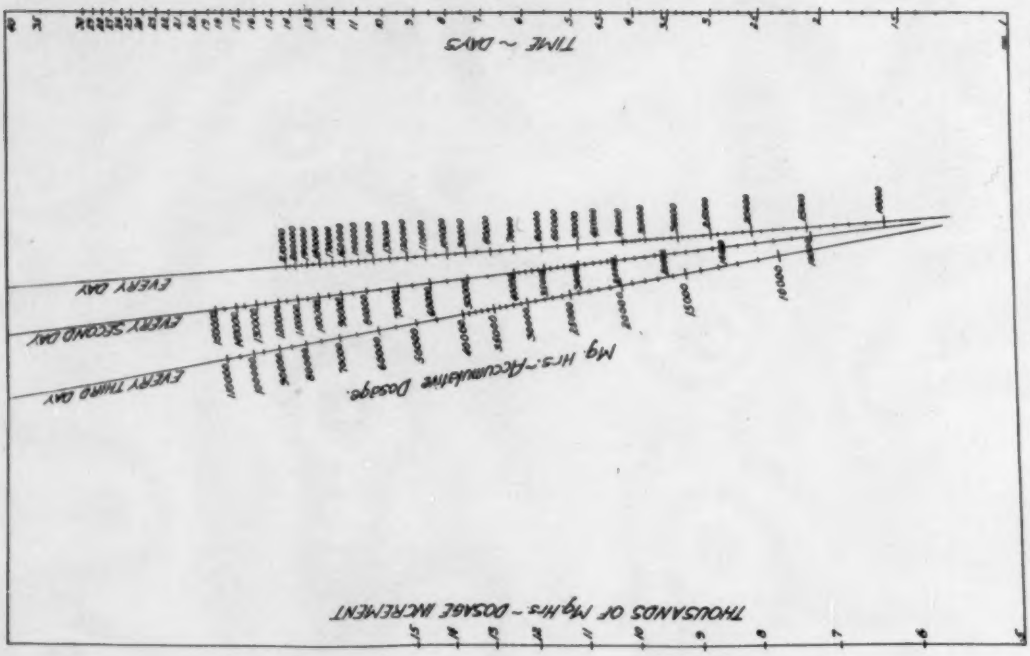

FIG. 2. Nomogram used in determining the cumulative dose from radium depending on dosage increments and time in days.

to know the cumulative dose each day, when internal irradiation or cross firing is resorted to.

Radium Packs. Using a loss of radiation effect of 4 per cent per day as used by Weatherwax[1] for radium filtered through 1 mm. of platinum, it is a simple matter to calculate the decrease of radiation effect by means of the equation $I_1 = I_0 e^{-\mu d}$ where, in this case μ is equal to 0.04. The other symbols have their usual significance as follows: I_1 = the final intensity; I_0 = the initial intensity; e is a constant = 2.718 and d is the time in days. However, when the treatments are divided as mentioned previously, the decrease in radiation effect is interrupted by successive additions so that the graph in Figure 1 represents a typical course of events during a series of treatments, when equal doses are given at regular intervals.

We have selected the peaks from curves of this type for time intervals of one, two, three, four and five days and for doses of 5,000 to 15,000 mg-hr. per treatment. These data are assembled in Table 1. The values given are the cumulative dose on the particular day plus the additional radiation.

The information assembled in Table 1 may be expressed in a more practical way in the form of a nomogram as shown in Figure 2. From this nomogram, the dosage at any time may be obtained by placing a straight edge across the known values for dosage increment and time interval and the intersection of the straight edge with the center scale will show the cumulative dose. Or, if it is desired to know on what day a certain dosage is reached, the process may be reversed.

Roentgen Rays. Similarly for roentgen rays of effective wave length 0.16 Å a nomogram (Fig. 3) has been constructed. In this case, however, the value of μ in the equation becomes 0.08 as determined by Stenstrom and Mattick[2]. The dosage in this nomogram has been calculated in roentgens (air scattering only).

[1] Weatherwax, J. L. Physics of Radiology. Paul B. Hoeber, New York, 1931.

[2] Stenstrom, W., and Mattick, W. L. Study of skin reactions after divided roentgen-ray dosage. Am. J. Roentgenol. & Rad. Therapy, 1926, *15*, 513–519.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

HAAS, LUDWIG. Über die nuchofrontale Aufnahme des Schädels. (On the nuchofrontal roentgenography of the skull.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1932, *45*, 532–557.

The author, a few years ago, described the so-called nuchofrontal technique for examination of the skull in which the central ray is directed from the nape of the neck through the frontal region. The method differs from the usual occipitofrontal technique in that the central ray is more angulated, depending on the anatomic conditions. It has the advantages that it gives a very good visualization of the sella turcica and its surroundings, of the pyramidal bones, foramen magnum and its surroundings (jugular fossa, atlas, lateral part of the occipital bone), of the posterior cranial fossa, especially of the cerebellar fossa, of the inferior portion of the occipital bone, of the vertex of the skull (sagittal and coronary suture, parietal and frontal bones) and of the conditions of the cranial cavity (pineal body and ventricles in case of encephalography). The method must be considered as an adjunct to the usual procedures of examination. By a slight modification of the angulation a position similar to that used in Stenvers' technique is obtained. The article is profusely illustrated.—*T. Leucutia.*

STUHL, L., DAVID, M., and PUECH, P. Les méningiomes de la convexité du cerveau: étude radiologique. (Meningiomas of the convexity of the brain: roentgen study.) *J. de radiol. et d'électrol.*, Jan., 1932, *16*, 5–23.

During the past three years the authors observed at the Pitié Hospital in Paris a total of 54 verified meningiomas, 21 of which were localized to the convexity of the brain. In these latter, roentgen signs were found in 16 cases that is, in 76 per cent (in 11 cases, that is, 52 per cent, the roentgen signs were detected preliminary to operation, whereas in 5 they were found only after operation).

The roentgen signs were dominated (A) by the osseous modifications due to extension of the tumor: (B) by osseous modifications secondary to hypervascularization, and (C) by calcifications within the tumor.

(A) According to Cushing the various types of osseous modifications due to extension of the tumor are represented by (1) thinning of the bone; (2) exostosis; (3) massive osteoma; (4) endostosis of the internal table; (5) invasion of the bone with hyperostosing reaction; (6) invasion with destruction, and (7) collar button-like meningioma with bone invasion. The authors themselves prefer to divide the osseous modifications due to invasion of the tumor as follows: (1) progressive thinning of the bone; (2) erosions; (3) osteogenic formations: (*a*) spicules and (*b*) hyperostosis.

(B) The osseous modifications secondary to hypervascularization are divided into (1) osseous straits and (2) vascular grooves.

(C) The calcifications represent a direct sign of the tumor but are observed only rarely. Their importance varies according to whether they infiltrate the entire extent of the tumor, leading to psammoma, or whether they are localized to parts of the tumor in the form of agglomerate opaque grains.

The article is illustrated with roentgenograms, photographs and reproductions of anatomic specimens. A bibliography of 23 references is appended.—*T. Leucutia.*

LÖW-BEER, ADALBERT. Intrakranielle Verkalkungen im Röntgenbilde. (Roentgen appearance of intracranial calcifications.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1932, *45*, 420–449.

The author describes in this article (1) the physiologic intracranial calcifications which occur (*a*) in the glandula pinealis, (*b*) in the plexus chorioideus, (*c*) in the Pacchionian bodies, (*d*) in the falx cerebri, (*e*) in the tentorium cerebelli, and (2) the pathologic calcifications which occur (*a*) in the meninges and (*b*) in the brain substance proper.

The conclusions are reached that the roentgen demonstration of calcifications facilitates the direct localization of intracranial processes.

For the differentiation of pathologic from physiologic calcifications an exact knowledge of the normal site of the physiologic calcifications is necessary. The displacement of such calcifications often forms an indirect sign of localization of a pathologic process. The displacement of the calcification of the glandula pinealis and glomus chorioïdeum is often very difficult to estimate. The calcifications of the falx cerebri as a rule appear spindle-shaped, the semilunar type representing an indirect sign of localization. Meningeal calcifications are observed as a result of inflammatory processes or following intracranial hemorrhage or in meningeal tumors. In chronic otitis media a calcification of the dura above the tegmen tympani, forming a sort of "encapsulated perforation," is not infrequently found. The roentgen examination only rarely permits a differentiation between a benign and a malignant meningeal tumor. The slow growth does not necessarily indicate histologic homoiotypia. Intracerebral calcifications are sequelae of specific and nonspecific inflammations, hemorrhages, parasites and tumors. Craniopharyngiomas show a rather typical arrangement of the calcium deposit, permitting a differentiation on the roentgen appearance alone. The size of the calcium focus does not permit any conclusions concerning the size of an intracranial tumor.—*T. Leucutia.*

Morquio, L. L'hémiplégie du kyste hydratique cérébral chez l'enfant. (Hemiplegia of cerebral hydatid cyst in children.) *Rev. sud-am. de méd. et de chir.*, Jan., 1932, *3*, 39–58.

Five cases of cerebral hydatid cyst leading to typical hemiplegia were observed in children. The 5 cases are described in detail and illustrated with roentgenograms and one pathologic specimen. The elements characterizing the syndrome of hemiplegia are as follows: (1) The hemiplegia is nearly always complete, there being a participation of upper and lower extremity and in a few instances paralysis of the inferior facial. In right-sided hemiplegias aphasia or alterations of speech which, as a rule, subside after operation may also be encountered. The hemiplegia is spastic, there being hypertonicity, exaggeration of the reflexes, clonus of the foot, epileptoid trepidation, Babinski sign, etc. In 3 out of the 5 observations it has developed in two times with various intervals. (2) The hemiplegia is, as a rule, complicated with loss of equilibrium, faulty motor coordination, etc. (3) The cranium presents irregularities on palpation, with areas of bone softening which are very tender to manipulation. The roentgenograms reveal a separation of the sutures with bony rarefaction, impressiones digitatae and occasional enlargement or complete destruction of the sella turcica. (4) The ophthalmoscopic examination shows invariably the presence of choked discs, indicating a progressive evolution of the process. Of the 5 cases 4 were operated on, resulting in 2 deaths and 2 cures. An early diagnosis is very important.—*T. Leucutia.*

Rigby, R. A. C. An intracranial dermoid cyst. *Brit. J. Radiol.*, April, 1932, *5*, 349–350.

The author briefly describes, using three roentgenograms for illustration, a case of intracranial dermoid cyst occurring in a male aged two and a half years. The unusual feature was the presence of numerous teeth in the neighborhood of the sella turcica and more posteriorly, and a shadow suggesting the outline of the cyst. No record can be found in the literature of an intracranial dermoid having been shown roentgenologically.—*T. Leucutia.*

Bernard, P.-M., and Sourice. Utilisation du "déplacement" ou méthode de Proetz pour l'exploration des sinus du crane. (Utilization of the "displacement" or Proetz method for the exploration of the sinuses of the cranium.) *Bull. et mém. Soc. de radiol. méd. de France*, Nov., 1931, *19*, 454–457.

In 1928 Proetz published a new method for the diagnosis and treatment of sinusites. His experiments were made in association with Le Mée who at that time was sent on a mission to the United States. Returning to France, Le Mée continued the work along the same line and recently, together with Bouchet, made a communication to the Annual Congress of the Society of Laryngology on the subject. The authors, being associated with this work, wish now to report the technique which is employed in France. Proetz, as is known, has since then written a book on the subject and Le Mée will shortly publish a monograph.

The principle of the method is as follows: Instead of introducing the radiopaque substance into the sinuses by means of an instrument such as a trocar or sound, as practiced heretofore, this is accomplished by displacing the air of the sinuses with the opaque substance by means of a negative pressure. The opaque substance is first instilled into one nasal

fossa and then the negative pressure is produced by intermittently obliterating one nostril and applying a source of aspiration (water bulb, air bulb, motor pump, etc.) to the other. Due to the modification of the pressure within the nasal cavity, the sinuses fill automatically, each air bubble being displaced by a like drop of the opaque substance—whence the name of "displacement" method. As can be seen, the state of the ostium is of paramount importance. If all the necessary precautions are taken, every sinus which does not permit the passage of the opaque substance may be considered pathologic. The time elapsing between the introduction of the fluid and its disappearance is, on an average, seventy-two hours, which therefore must be considered as the normal time of evacuation.

Three conditions are essential for the examination to be successful: (1) all sinuses must be visible on the films; (2) they must be projected in their entirety in the three dimensions, and (3) the position of the tube, film and patient must remain mathematically fixed, that is, must remain unchanged for a given incidence at all examinations.

Various apparatus were constructed embodying these principles (Ernst, Allen, Baum). The authors use four incidences, the horizontal ray passing each time through the base line which unites the nasofrontal suture with the external auditory meatus (the patient being in a sitting position and the tube tilted horizontally): (1) suprainial incidence for the frontal and ethmoidal sinuses; (2) infrainial incidence for the maxillary sinuses (same incidence, except that the mouth is kept wide open, being used for the base of the sphenoid sinus); (3) lateral incidence with the head at 90° rotation, the base line remaining horizontal, and (4) submental-vertical (ground plane) incidence, the base line being vertical (head inclined backward) and the horizontal ray being centered underneath the chin.

According to Le Mée and Bouchet, the method has the following advantages: (1) it makes use of the weight of the fluid which penetrates into all cells regardless of their normal or abnormal situation; (2) the introduction of the fluid is obtained without instruments, that is, without traumatism or secondary reaction; (3) the introduction is general, permitting a comparison of the two sides; (4) an easy distinction can be made between the so-called medical and surgical cases; (5) the method may be used both for diagnostic and therapeutic purposes.—*T Leucutia.*

Source. Présentation d'un appareil permettant l'exploration radiologique des sinus du crâne préalablement remplis de liquide opaque (Méthode de Proetz). (Presentation of an apparatus permitting roentgen exploration of the sinuses of the cranium preliminarily filled with opaque liquid—method of Proetz.) *Bull. et mém. Soc. de radiol. méd. de France.*, Dec., 1931, *19*, 494–497.

The author in this article describes a special apparatus which was constructed by Massiot for the roentgenography of the accessory sinuses of the skull according to the Proetz method (see above abstract). Similar apparatus were constructed by Ernst, Allen and Baum.

The apparatus has certain new features. Thus, it is composed of two statives, one for the support of the tube and the other for the support of the screen. This latter is used for exact centering and is replaced by the film cassette when the roentgenogram is made. The tube can be angulated to any of the desired positions and strictly immobilized. The apparatus is described in detail and illustrated with a photograph.—*T. Leucutia.*

Le Mée, J.-M., and Bouchet, M. La methode de "déplacement" ou de Proetz dans le diagnostic et le traitement des sinusites. (The "displacement" or Proetz method in the diagnosis and treatment of sinusitis.) *Presse méd.*, March 12, 1932, *40*, 394–396.

The so-called "displacement" method consists in substituting the normal air of the sinuses with a fluid which might be a drug in case of therapy or a radiopaque substance in case of diagnostic procedure. This indicates that the method might be used (1) for therapeutic considerations and (2) for diagnostic purposes. Proetz, in 1925, elaborated the diagnostic procedures and after perfecting the technique, he has now established a standard method.

The authors describe in detail (1) the principles of the method; (2) the technique, such as preparation of the patient, instrumentation, position during roentgen examination, roentgen apparatus, etc.; (3) the interpretation of the results obtained, such as diagnosis of sinusitis, the importance of the state of the ostium and of the time of evacuation, and (4) the therapeutic utilization. They conclude as fol-

lows: The method of Proetz presents a certain number of advantages: (1) it is neither painful nor injurious, the only foreign body introduced within the nasal cavity being a fluid which penetrates into the sinuses by gravity; (2) all sinuses are injected, this permitting the detection of aberrant cells which are often the seat of origin of pathological processes; (3) the introduction of the opaque substance is general, this making possible the comparison of all sinuses of one or both sides; (4) it is a method which simplifies the lipiodol diagnosis of paranasal cavities and completes it by the study of the time of evacuation; (5) it permits a rapid separation of medical and surgical cases, thus forestalling unnecessary or uncomfortable operations. Every sinus which fills is to be treated medically, while those which despite the necessary precautions show non-filling should be treated surgically; (6) it conforms to the modern ideas tending to supplement the clinical examination with a system of functional and graphic tests; it therefore represents for the sinuses what tetraiodophenolphthalein does for the biliary tract or uroselectan for the renal system; (7) from the therapeutic standpoint it respects the ostium which according to the anatomists represents the most important vascular nervous point dominating the entire pathology of the sinuses; (8) it represents a logical therapeutic procedure of sinus infections inasmuch as it acts directly on the mucosa.—*T. Leucutia.*

NECK AND CHEST

Heuser, Carlos. L'arteriographie. (Arteriography.) *Bull. et mém. Soc. de radiol. méd. de France*, May, 1932, *20*, 284–291.

The author performed a series of experiments on rabbits, dogs and monkeys, for the visualization of the arterial system by injecting lithium carmine and isamine blue, in conjunction with colloidal thorium. The lithium carmine was found to be very toxic and was therefore abandoned. The isamine blue gave quite satisfactory results although this preparation has the inconvenience that it is decomposed above 80° and therefore it cannot be sterilized by boiling. The remarkable fact was that neither the colloidal thorium nor the isamine blue produced satisfactory shadows when injected separately but they gave the desired result when injected together. In this manner not only a good visualization of the blood vessels but a very intense impregnation of the liver and spleen was obtained with a rather small dose within a short period (8 hours). The method also gave very good visualization of the descending aorta. As stated above its only disadvantage is that the isamine blue is decomposed by heat and therefore the solution must be always prepared fresh, a procedure which is somewhat cumbersome. The technique is as follows: first day, intravenous injection of 2 c.c. of isamine blue on an empty stomach; second day, injection of 25 c.c. thorotrast and immediately afterwards of 2 c.c. isamine blue. Ten hours later a first roentgenogram of the liver is made; third day, rest; fourth day, second injection of 25 c.c. thorotrast and immediately afterwards of 2 c.c. isamine blue. Following this second injeotion a roentgen visualization of the pulmonary arteries and descending aorta is obtained.

By using the above-described method the author was able to obtain hepatolienography, arteriography and impregnation of the vessels in the human without any danger. Although during the few months that the method has been employed no inconveniences have been observed, the author does not wish as yet to affirm that the method is entirely harmless.—*T. Leucutia.*

Ravina and Sourice. Étude expérimentale de l'artériographie pulmonaire. (Experimental study of pulmonary arteriography.) *Bull. et mém. Soc. de radiol. méd. de France*, March, 1932, *20*, 129–132.

The authors carried out a series of experiments on dogs by injecting the pulmonary arteries through a sound which was introduced through the internal jugular vein directly into the right ventricle of the heart. The material first used was sodium iodide in a 30 to 70 per cent concentration, and abrodil and tenebril later. It was found that the best opacity is obtained from the sodium iodide. Because of the danger connected with embolism the method, at least for the time being, has to remain purely experimental.—*T. Leucutia.*

Cremer, Valentine. Volumineux kyste gazeux congénital du poumon chez un enfant. (Voluminous air cyst of the lung in a child.) *Bull. et mém. Soc. de radiol. méd. de France*, April, 1932, *20*, 203–205.

Cases of voluminous congenital air cysts of the lung are exceedingly rare. A review of the literature hardly reveals 30 cases. The author

had the opportunity to observe such a case in a boy fifteen years of age, the cyst having occupied practically the entire right hemithorax. It is interesting that the condition was first diagnosed as a spontaneous pneumothorax. The diagnosis of air cyst was made from the fact that the lower border of the cyst was well demonstrated and that the cardiovascular and hilar shadows were displaced towards the opposite side, in a manner suggesting pressure from a rounded cyst.

It is only exceptional that such cases attain the ages of fifteen to twenty years, the majority succumbing to intercurrent grip or bronchopulmonary infection.—*T. Leucutia.*

Meller, Oscar. Câte-va tipuri de reacţiune perifocală în adenopatia tuberculoasă la copil. (Certain types of perifocal reaction in tuberculous adenopathy in children.) *Bul. soc. de radiol. si electrol. med. din Romania*, March, 1932, *1*, 5–9.

The author, on the basis of clinical and autopsy material, wishes to draw attention to the so-called perifocal reaction around tuberculous hilar glands in children. In its simplest form, this reaction appears as an accentuation of the alveolar or polygonal markings around the hilus and may be irreversible or reversible. In the first case, the substratum is formed by an interlobar fibrous connective tissue, whereas in the second it is the result of an edema. Experimental investigations carried out by the author in association with Menkes proved beyond doubt that interlobar connective tissue when saturated with water becomes roentgenologically visible. In a more advanced form, the reaction appears as a homogeneous shadow within the pulmonary field extending from the hilus towards the periphery and occasionally involving an entire lobe. The evolution in most instances is benign, a *restitutio ad integrum* resulting. In one of the cases it took nearly fourteen months before the resorption became complete, indicating that the reaction might last for a long period.

The differential diagnosis includes a primary lesion, early parenchymal infiltration, hilar pneumonia, etc.

The reaction may also occur within the glandular mass or along the interlobar septa. In the first, a more or less temporary tumefaction of the involved glands, in the second, a so-called fibrous scissuritis or even an interlobar collection of fluid may result.—*T. Leucutia.*

Thoyer-Rozat, P., and Delherm, L. Du rôle social du radiodiagnostic dans le dépistage de la tuberculose pulmonaire. (The social rôle of roentgen diagnosis in detection of pulmonary tuberculosis.) *J. de radiol. et d'électrol.*, March, 1932, *16*, 111–113.

The authors advise that periodic roentgen examinations of the chest be made at various ages and occasions to detect unsuspected early tuberculous lesions. Thus they believe that these examinations could be performed (1) in school children once a year when admitted to the next grade; (2) in adolescence when admitted to the various schools of specialty (nursing schools, universities, etc.); (3) in adults when admitted to the military service, when obtaining a marriage certificate or when applying for life insurance, driver's license, or asking admittance to various enterprises (banks, railroads, mines, etc.).—*T. Leucutia.*

Murdoch, J. Diagnostic radiologique des tumeurs pulmonaires. (Roentgen diagnosis of pulmonary tumors.) *Cancer, Brux.*, 1931, *8*, 150–160.

Whereas in the second half of the last century only 5 per cent of pulmonary tumors could be diagnosed during life, the percentage has now increased to over 50, thanks to the contribution of the roentgen method.

I. Primary tumors of the lung. (1) Pulmonary carcinoma (bronchial carcinoma). A. Direct signs. These consist in the demonstration of the roentgen shadow corresponding to the actual tumor. The author differentiates (*a*) an intrabronchial stage; (*b*) cancerous pneumonia; (*c*) hilar carcinoma; (*d*) lobar carcinoma; (*e*) cancerous lymphangitis, and (*f*) intralobar nodular carcinoma, the appearances being described in detail for all these forms. B. Secondary signs. (*a*) Bronchial stenosis by the obstructing neoplasm which may lead to mediastinal, diaphragmatic and pulmonary phenomena. The mediastinal phenomenon consists in displacement of the mediastinal shadow towards the diseased side, a pendulum-like migration being not infrequently observed at the roentgenoscopic examination. It is necessary, however, that the bronchial lumen be reduced at least one-third of the normal diameter. The diaphragmatic phenomenon consists in elevation of the diaphragm leaf and limited excursion. According to Lenk, the changes of the diaphragm are due to paralysis of the phrenic nerve from metastatic compression rather

than to bronchial stenosis. The pulmonary phenomenon consists in compensatory emphysema which is occasionally associated with a curious valve-like action, the air being able to enter the portion of the lung distal to the obstruction but being unable to leave because of complete obstruction produced by the partly movable tumor. (*b*) Pulmonary metastases. Secondary metastases within the lung parenchyma from a primary bronchogenic carcinoma are not altogether rare. (*c*) Pleural effusion. This is observed in the more advanced cases and it may occur either freely in the pleural cavity or may be encysted or, finally, may be interlobar. (2) Pulmonary sarcoma. This condition is so rare that several authors deny its existence. The roentgen appearance shows great analogy to that of carcinoma. (3) Lymphogranulomatosis which may have a miliary and nodular form, primary leucemia, benign tumors and cysts are conditions which give a more or less characteristic picture.

II. Secondary tumors of the lung. These are classified as (1) secondary metastatic lymphangitis; (2) miliary metastases; (3) solitary nodular metastases; (4) multiple nodular metastases, and (5) irregular metastases.

III. Auxiliary methods of examination. These consist in bronchography, pneumothorax and the so-called therapeutic test dose.—*T. Leucutia.*

Canigiani, Th. Zur Röntgendiagnostik des Aneurysma dissecans der Brustaorta. (Roentgen diagnosis of dissecting aneurysm of the thoracic aorta.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1932, *45*, 416–420.

Two cases of dissecting aneurysm of the thoracic aorta, which were examined roentgenologically, are briefly described and discussed in view of the autopsy findings. One of the cases represented a circumscribed aneurysma dissecans sacciforme and the other a diffuse cylindrical aneurysm. Concerning the roentgen appearance, the author expresses the opinion that the diffuse cylindrical dissecting aneurysm is recognized only rarely, whereas the sacciform type is recognized more frequently because of calcium deposit in the wall or because of the type of pulsation of the shadow seen roentgenoscopically. Differential diagnosis includes mediastinal tumors, dermoid cysts, intrathoracic struma, carcinoma of the hilus, neurogenic tumors and occasionally esophageal carcinoma.—*T. Leucutia.*

Boller, R., and Pape, R. Zur Diagnose des Herzaneurysmas. (Diagnosis of aneurysms of the heart.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, March, 1932, *45*, 318–327.

The authors describe a case in which a clinical diagnosis of luetic insufficiency of the aorta was made but which on roentgen examination showed a marked enlargement of the right border of the heart, suggesting because of its atypical appearance the possibility of an aneurysm. Post-mortem examination confirmed the roentgen diagnosis, except for the fact that the aneurysm was located to the ventricular septum, which was displaced to the right, producing a secondary displacement of the right border of the heart from pressure. In addition, there was mesaortitis with aortic insufficiency and coronary sclerosis. The most interesting feature of the case, however, was that there was no dilatation of the right ventricle itself.

In connection with this case, the author discusses the positive roentgen signs of cardiac aneurysm which result from changes in (1) position, (2) size and form, (3) pulsation and (4) secondary manifestations brought about by the growing aneurysm. These signs are encountered (1) in aneurysms with contour formation, (2) in aneurysm of the septum, (3) in intracardiac aneurysms localized to the sinus valsalvae and (4) in aneurysms with calcified parietal thrombi. (5) In doubtful cases the presence of coronary sclerosis may help to substantiate the diagnosis.—*T. Leucutia.*

Routier, Daniel, and Heim de Balsac, R. Aspects radiologiques du coeur dans les endocardites mitrales rhumatismales. (Roentgen aspects of the heart in rheumatic mitral endocarditis.) *Bull. et mém. Soc. de radiol. méd. de France*, April, 1932, *20*, 197–200.

For the past fifteen years cardiologists paid attention chiefly to the mechanical conditions created by the valvular lesions. Thus they considered the cardiopathies as entirely dominated by the intracardiac hydraulic disorders developing secondary to the valvular strictures and resulting in hypertrophy, later dilatation and insufficiency. This conception directed the roentgen investigator toward the detection of signs which would permit the clinician to affirm the valvular lesion and to make a differentiation between insufficiency and stenosis, which appeared to be of paramount importance. At the present time the theory of stabilized or evolutive inflammatory process has practically re-

placed the purely mechanical conception. According to this, the inflammation extends, in addition to the valves, to the adjoining myocardium and occasionally to the pericardium. Because of the changes produced within the muscle the mechanical causes are permitted to act on the walls, thus producing dilatation with certain well-defined deformities of the contours of the cardiovascular shadow. In viewing the problem thus, the rheumatic mitral endocardites form a homogeneous nosologic group which includes the old subdivisions of stenosis, insufficiency or mitral disease. The myocardial alterations being localized nearly always to the same region of the heart, especially to the left auricle, the roentgen deformities present a more uniform aspect. The authors insist chiefly on two signs which are of great value: (1) the prominence of the left auricle as viewed in the transverse position and (2) the venous stasis at the hilus and roots of the lungs as viewed in the posteroanterior position.—*T. Leucutia.*

Routier and Heim de Balsac. Aspects radiologiques du coeur dans les endocardites mitrales rhumatismales. (Roentgen aspects of the heart in rheumatismal mitral endocardites.) *Bull. et mém. Soc. de radiol. méd. de France*, May, 1932, *20*, 271–276.

In this second communication, the authors present cases of rheumatic mitral endocarditis which, because of the lack of inflammatory involvement of the myocardium, failed to produce roentgen deformities of the cardiac shadow. The auscultative findings were identical with those of the cases presented in the first communication but the heart appeared of normal volume or only slightly enlarged in size. Although occasionally there was a slight elongation of the median arc in the posteroanterior view, this did not increase in the right anterior oblique rotation. Likewise the left auricle did not protrude into the retrocardiac space and there was no evidence of venous stasis at the hilus.

The conclusion is drawn from these two communications (1) that a roentgen silhouette which is characteristic of a definite mitral valvular lesion does not exist; (2) that a roentgen examination cannot and should not establish a diagnosis of a valvular lesion, and (3) that the myocardial reaction is the factor chiefly responsible for the form and volume of the heart. In this manner, the roentgen examination, although often in disagreement with the physical signs, is, as a rule—but not always—in harmony with the cardiovascular functional disorders.—*T. Leucutia.*

Cossio, Pedro. L'image radiographique de la fibrillation auriculaire. (Roentgenographic image of auricular fibrillation.) *Rev. sud-am. de méd. et de chir.*, Jan., 1932, *3*, 19–28.

On the basis of 15 personal observations (one of which was controlled at autopsy), the author describes a typical roentgen picture of auricular fibrillation which is as follows: There is a mitral configuration of the left contour of the heart associated with a double arc of the right contour. The mitral configuration consists in an exaggeration of the median arc with a lowering of point G as compared to point D; the double arc is the result of the projection of the enlarged left auricle representing the superior arc and of the projection of the right ventricle representing the inferior arc.

Dilatation of the auricles is a rather common finding in the autopsies of all individuals who during life presented an auricular fibrillation. Conversely, one may assume that whenever there is a marked auricular dilatation and whenever the above typical roentgen image is encountered, one may assume the presence of auricular fibrillation. In the author's cases this was confirmed in every instance by electrocardiography. This of course does not indicate that all cases of auricular fibrillation give the above said typical roentgen picture since many of the auricular fibrillations are not associated with dilatation of the auricles. But one can affirm with certainty that whenever the dilatation of the left auricle oversteps the right contour of the cardiac silhouette producing the second arc above that of the right ventricle an auricular fibrillation may be diagnosed.—*T. Leucutia.*

Haret and Frain. A propos de l'examen radiologique du coeur (étude quantitative). (Concerning the roentgen examination of the heart; quantitative study.) *Bull. et mém. Soc. de radiol. méd. de France*, Jan., 1932, *20*, 35–39.

In studying the diameters of the heart as measured on the cardiac silhouette, one must take into consideration that the distance of the plane of the greatest diameters from the plane of the film (in the posteroanterior view) varies for every individual, and that the average distance which is taken in the routine examination

carries a greater or lesser degree of error. The author, aiming to obtain the exact value of the diameters of the heart as measured in teleroentgenograms, corrected the above error by introducing the so-called "index of correction." This is determined by first roentgenoscopically marking point G (in the exact posteroanterior position) with an opaque landmark and by estimating the difference of the displacement of the end of the greatest diameter when two exposures are made on the same film, the tube being moved for a certain distance (1 cm. for every 10 cm. focus film distance) parallel with the plane of the film. The formula of the index of correction thus obtained is $d/d+a$ in which d represents the distance of focus displacement and a the distance displacement of the end of the greatest diameter. The method is very similar to that used for the localization of foreign bodies.—*T. Leucutia.*

Giannelli, V. Ricerche radiologiche sul volume del cuore e sull'indice cardiaco individuale nei bambini dai 6 ai 12 anni. (Roentgen research on the volume of the heart and individual cardiac index in children from six to twelve years.) *Diario radiol., Torino,* Nov.–Dec., 1931, *10,* 161–178.

The methods employed for determination of the volume of the heart may be roughly divided into two divisions: (1) those which make use of the orthodiagram and teleroentgenogram by basing the measurements on various landmarks of the border of the heart or on the calculation of the surface area of the frontal section, and (2) those which approximate the heart to certain well-known geometrical configurations and estimate the volumetric dimensions by mathematical calculation. To this latter group belongs the method of Salotti, which is used by the author in his investigations. Salotti by comparing the heart to an ellipsoid divided it into four segments (the dividing lines being the diameters of the heart) and obtained the following formula:

$$V=\frac{a+b}{2}\cdot\frac{\pi}{3}(bc+ca+ad+db).$$

He calculated the volume as follows: Inasmuch as $\pi/3=1.0472$, which may be taken roughly as 1, the formula may be changed to

$$V=\frac{a+b}{2}(bc+ca+ad+db)$$

and again to

$$V=\frac{a+b}{2}c(a+b)d(a+b)$$

and finally to

$$V=\frac{a+b}{2}(a+b)\cdot(c+d)$$

in which a and b represent the two halves of the transverse diameter as measured from the usual right inferior and left superior points of the border of the heart to the longitudinal diameter and c and d represent the two parts of the longitudinal diameter of the heart from point D' and apex respectively to an intermediary point which lies in the middle between the two points of intersection of the halves of the transverse diameter. Thus the procedure is very simple and a single orthodiagram or a teleroentgenogram suffices. After defining the usual landmarks of the border of the heart, the diameters are drawn in the usual way and thus the definition into the four segments forming the basis of the above formula is made.

The author, by making use of the teleroentgenogram, and in a few instances also of the orthodiagram, extended his investigations to 300 children between six to twelve years of age, and arrived at the following conclusions: (1) the infant heart between six and twelve years is considerably larger in comparison to the body than that of the adult; (2) in girls the average dimensions of the heart are both in a relative and absolute sense smaller than in boys of the same age; (3) the volume of the heart and the individual cardiac index appeared larger in the group of children which were younger but normally developed than in the group of older children with signs of relative over-development; (4) the decrease in girls as compared to boys reached its maximum between the ages of nine and twelve. This most probably is due to the earlier development of puberty; (5) with advanced age the difference in the increase of the right ventricle above the left becomes less evident —*T. Leucutia.*

Delherm, Thoyer-Rozat, Codet, P.-H., and Fischgold. Notes sur quelques acquisitions nouvelles de la kymographie cardio-vasculaire. (Notes on some new findings in cardiovascular kymography.) *Bull. et mém. Soc. de radiol. méd. de France,* May, 1932, *20,* 263–270.

Continuing their work on kymography, the authors found that the method permits a pre-

cise study of the silhouette and especially of the left border of the heart. A differentiation between the great vessels, the left auricle and ventricle is easily made. Likewise, point *G* which lies between the auricle and ventricle and the median arc are determined with nearly mathematical precision. The method is further of value in the oblique and the transverse examination of the heart, inasmuch as it permits the dissociation of the shadows of the great vessels in the oblique and the study of the pulsations transmitted to the barium-filled esophagus in the transverse position.—*T. Leucutia.*

ABDOMEN

Coliez, Robert. Dynamique biliaire. (Biliary dynamics.) *Cahiers de radiol.*, Jan. 15, No. 4, 1931.

The author describes in detail 6 cases, using numerous roentgenograms and sketches for illustration, to prove that a serial roentgen examination has great value in the study of mobile calculi of the gallbladder, and especially in the estimation of the mobility of the gallbladder in various positions.

Briefly, one may say that the organs of the right upper quadrant are subjected to the law of gravity, the liver, gallbladder and the biliary calculi, if such are present, assuming various positions according to the position of the patient. On recumbent position the inferior extremity of the gallbladder appears generally at the level of the second and third lumbar vertebrae; by changing from the ventral into dorsal decubitus the inferior border of the liver as well as the gallbladder rises slightly. In the erect position both the lower lobe of the liver and the inferior border of the gallbladder descend considerably, even reaching the level of the iliac crest.

If the gallbladder incloses free calculi, the density of which is higher than that of the bile, the calculi follow the law of gravity, that is, they descend toward the fundus in the erect position and mount toward the cystic duct in the recumbent or Trendelenburg position, the opposite being true of the calculi which are lighter than the bile. If in the lateral view the shadows are close to the abdominal wall, one may assume the presence of biliary calculi, although occasionally the presence of renal calculi in an anteriorly displaced kidney cannot be excluded. Intravenous pyelography in such instances will, as a rule, elucidate the question. If the gallbladder appears fixed to the anterior abdominal wall (as demonstrated either by pneumoperitoneum or by the gallbladder dye method), one may assume the presence of extensive perivisceritis with adhesions of the anterior parietal peritoneum.—*T. Leucutia.*

Held and Meese. Die Leberzirrhose im Röntgenbild nach Thorotrastinjektion. (The roentgen appearance of liver cirrhosis following thorotrast injection.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1932, *45*, 451–456.

Thorotrast was injected in 7 cases, 2 of which died from bronchopneumonia and pyelocystitis respectively. The 7 cases are briefly described and discussed. The conclusion is reached that the roentgen diagnosis of cirrhosis of the liver by means of thorotrast injection represents the surest method. The danger is relatively small, except in cases of infection. The thorotrast storage was determined by the bilirubin test and by the Congo-red storage. A differentiation of stasis from hyperplasia of the spleen was obtained with the aid of adrenalin injection. It is the authors' contention that the method may be used for the study of the various stages of cirrhosis of the liver.—*T. Leucutia.*

Fetzer, H. Die Hepato-Lienographie in Verbindung mit der Cholezystographie und Pyelographie. (Hepato-lienography in connection with cholecystography and pyelography.) *Fortschr. a d. Geb. d. Röntgenstrahlen*, March, 1932, *45*, 328–330.

The observations refer to patients who received 60 c.c. of thorotrast, and later intravenous uroselectan and iodtetragnost. It was found that the storage of the thorotrast in the liver and reticulo-endothelial system did not influence the elimination of the iodtetragnost from the biliary system or the excretion of the uroselectan from the renal system. Three roentgenograms showing simultaneous visualization of the liver, gallbladder and kidney are reproduced.—*T. Leucutia.*

Camplani, Mario. Contributo alla conoscenza della rare immagini colecistografiche. (Some rare cholecystographic pictures.) *Radiol. med.*, Jan., 1932, *19*, 38–45.

The author briefly reviews the congenital or acquired anomalies that may be seen in cholecystography and describes a case in a woman of thirty-eight who was sent to him for chole-

cystography on account of vague symptoms in the liver region. The picture showed a pear-shaped bladder almost normal in size but divided into two parts, an upper and a lower. He concluded that this was due to a constricting band brought about by pericholecystitis. He thought there were probably adhesions between the duodenum and gallbladder and that laparotomy was required. Operation showed a gallbladder somewhat smaller than normal with evident signs of cholecystitis. It contained only a little bile, normal in appearance, and no calculi. There was a band of fibrous tissue stretched from one wall to the other dividing it into a lower and an upper part. He does not know whether this was a congenital anomaly or whether the band was a result of inflammation from a stone that had been passed.—*Audrey G. Morgan.*

VITA, GIULIO. Contributo allo studio della linite plastica. (Study of linitis plastica.) *Radiol. med.*, Jan., 1932, *19*, 63–74.

The author describes a case of plastic linitis that he studied clinically and roentgenologically in which the diagnosis was confirmed by autopsy and histological examination. This is a benign condition first described by Brinton. He then discusses the differential roentgen diagnosis between linitis, scirrhous carcinoma, syphilis and tuberculosis of the stomach, cicatricial contractions and intoxications. The diagnosis of linitis is made chiefly from the internal relief of the gastric mucosa, the motility of the stomach and the disproportion between the infiltration of the stomach wall and the general health which is good. He concludes that with very careful roentgen examination the disease can be diagnosed during life.—*Audrey G. Morgan.*

MCCLURE, C. C. Diseases of the large intestine *Arch. Surg.*, March, 1932, *24*, 411–425.

This is a general discussion of the more common conditions encountered in the routine examination of the gastrointestinal tract. Among the introductory remarks the fact is brought out that a transverse colon that crosses the upper part of the abdomen is more or less rare. In the majority of cases, one finds that the colon falls well below the umbilicus.

Spastic Colitis. The etiology has not been ascertained. Many competent clinicians ignore its existence. The author believes it to be a real entity and one that can be definitely demonstrated. Spastic colitis is a functional condition that may give rise to numerous symptoms, the most common of which is constipation. In the presence of the constipation, it is surprising to learn that often there is marked colonic hypermotility. According to Gauss, several theories have been advanced to explain hypertonicity. "The direct etiologic factor is an open problem today. Nevertheless, it has been observed that usually the patient with a spastic colon is a neurotic individual given to introspection, and that the hypertonicity of the colon is a local manifestation of a general spasmophilic tendency."

Ulcerative Colitis. It is probable that ulcerative colitis is caused by an infection that has been superimposed on tissues the resistance of which has been lowered as the result of a predisposing condition, such as long-standing catarrhal inflammation of the bowel or severe spasticity of the colon. The disease is apt to be sudden in its onset, with lancinating pains over the course of the colon, accompanied by griping and frequent bowel movements, and severe constitutional symptoms. The attacks occur in cycles and after a while, mucus, pus, and blood are passed. This condition may be confused with dysentery, typhoid fever or a malignant process. Cancer develops much more slowly than ulcerative colitis, and pain and griping are rarely seen early in malignant disease. In a case of carcinoma the patient is comfortable after the bowels have moved, except in the late stages of the disease, while in colitis a bowel movement fails to give relief.

Pericolitis. The chief symptoms are constipation, alternating with occasional diarrhea, consitutional disorders resulting from absorption, localized abdominal soreness or pain on pressure, a palpable mass, which may readily be mistaken for a tumor, and mucus or blood in the stools. The condition must be differentiated from appendicitis, diverticulitis and cholecystitis. This may often be accomplished by means of a barium sulphate enema, although in diverticulitis the enema is not so important as the twenty-four hour barium examination, since barium sulphate when given by mouth is so much more certain to fill a diverticulum than when given by enema.

Appendicitis. The author does not wish to imply that all cases of appendicitis can be diagnosed by roentgenography, but many cases cannot be diagnosed preoperatively by any other method. The cases in which the roentgen

study is of value are those in which there is a history of vague abdominal uneasiness or distress, with a digestion that is not up to par. The demonstration of a retrocecal appendix with its tip high up under the hepatic flexure will serve to differentiate appendicitis from cholecystitis. The presence of stones in the appendix also can be demonstrated, as well as adhesions that prevent the free movement characteristic of the normal appendix. It is not often that the appendix is found in the classic McBurney position. Delayed emptying of the appendix (from twenty-four to seventy-two hours after the head of the colon has emptied) is thought by some authorities to be evidence of chronic appendicitis.

Foreign Bodies. The progress of opaque foreign bodies can be followed through the intestinal tract by serial roentgenograms and roentgenoscopic examinations.

Tuberculosis. This is in the majority of instances secondary to a primary focus in the lungs, larynx or pharynx. Primary lesions usually develop in the cecum or anus. The predilection of tuberculosis for the large bowel is attributed to the greater speed of the intestinal content through the small bowel, which does not permit the bacilli to find lodgment there; attenuation of the bacilli by the gastric juices, their virulence not being recovered until the cecum or colon is reached; the alkaline reaction of the feces after the ileocecal region is attained, which provides a more propitious environment for the bacilli; the formation of hardened masses of feces in the cecum, which traumatize the mucosa and produce conditions favorable to infection, and the abundant lymphatic distribution in the ileocecal region, which favors the development of tuberculosis.

Several types of tuberculosis are found in the colon, the most common of which are the hyperplastic, ulcerative and miliary. The hyperplastic type occurs most frequently in the third decade. It produces a slow-growing tumor which at times is quiescent for two or three years before it attains sufficient size to occlude the lumen of the bowel. These tumors usually feel smooth when palpated and are usually fixed. The rigidity of the terminal ileal segment is a characteristic roentgenographic observation.

In the ulcerative type, the disease may progress rapidly. The mixed infection that must follow soon causes toxemia, imperfect digestion, constitutional manifestations, persistent diarrhea and extensive destruction of the mucosa and deeper bowel coverings.

When miliary tuberculosis of the intestines occurs the prognosis is unfavorable because it is secondary to a well-established process elsewhere, and the patient is debilitated and unable to withstand the ravages of the fast-spreading process.

Diverticula. A diverticulum is a non-neoplastic outpouching of intestine, having a lumen that connects with the bowel or that formerly connected with it. They may be congenital (true) or acquired (false), the latter occurring between the ages of forty and sixty and about twice as frequently in men as in women. They may occur in any portion of the colon, may be large or small, single or multiple, smooth or irregular. They may be without symptoms or may simulate other intra-abdominal conditions. Diverticulitis is often mistaken for carcinoma. Proctoscopic examination may reveal a small opening from which pus is draining, and pus in the bowel is suggestive of diverticulitis. It is often impossible to make the differentiation on the basis of the roentgen examination alone, but the small cavitation that is present in carcinoma is rarely seen in diverticulitis.

Carcinoma. Unfortunately, early carcinoma of the colon is difficult to diagnose roentgenographically, as a filling defect does not develop until the late stages of the disease. Patients suffering from early carcinoma seldom present themselves for roentgen examination. Fully developed cancer of the colon usually produces fairly typical symptoms. It is often difficult to pass any of the opaque medium through the area of partial obstruction by enema, though a small amount may pass the obstruction when the barium is given by mouth. When cecal carcinoma is suspected, a delay in ileal emptying is a significant sign.—*Karl Kornblum.*

Floris, Michele. Contributo allo studio clinico e radiologico delle affezioni del colon sigmoide nella donna, con speciale riguardo alla sindrome spastica. (Clinical and roentgen study of diseases of the sigmoid colon with special reference to the spastic syndrome:) *Radiol. med.*, Jan., 1932, *19*, 52–62.

On the basis of 30 cases of anatomical and functional anomalies of the sigmoid colon which he has studied clinically and roentgenologically the author discusses the frequency of such conditions and particularly spastic functional dis-

turbances. The importance of these lies in the fact that they may very readily be mistaken for lesions of the internal female genitalia. Roentgen examination is of great value in making the differentiation. The therapeutic test with belladonna, which is a valuable antispasmodic, is also of importance.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

Truchot, P. L'artériographie rénale. (Renal arteriography.) *Bull. et mém. Soc. de radiol. méd. de France*, Dec., 1931, *19*, 493–494.

Dos Santos, Lamas and Caldas of Lisbon in 1929 introduced renal arteriography by injecting 100 per cent sodium iodide directly into the abdominal aorta (the injection being made at the costovertebral angle underneath the 12th rib, 8 cm. lateral from the median line). The author practised the method in 20 cases with quite satisfactory results. The only accidents observed were a slight iodism in one case and a mild nephritis with temporary increase of the blood nitrogen and edema in another.

The findings were interesting. Those lesions which produced ischemia or hypervascularization usually led to characteristic images while others, which were very complicated and in which no other methods were practicable, were often considerably aided by the use of this new method. Valuable information was obtained especially in two groups: (1) in renal tuberculosis in which the site of the lesion could be localized exactly, thanks to the diminution of blood supply of the part of the kidney involved, and (2) in hematurias due to beginning neoplasm in which the area of hypervascularization permitted the detection of the neoplasm in its earliest stages.

The conclusion is drawn that the method, although still of very limited use, is of certain value in very well-selected cases.—*T. Leucutia.*

Coliez, Robert, and Bergmann, O. Une nouvelle méthode de radiographie du système urinaire par l'uroselectan. (A new method of roentgenography of the urinary system by uroselectan.) *Cahiers de radiol.*, Oct. 1, No. 3, 1930.

After describing the technique of injection as well as the roentgenographic procedure, which is that now usually employed, the authors arrive at the following conclusions: Roentgenography of the urinary system by the intravenous injection of uroselectan is of great value. A retarded excretion signifies renal insufficiency. If only one kidney and its ureter is visualized there is a loss of function or absence of the other kidney. The procedure gives images which are more physiologic but for the same reason less precise and informative. The localization of calculi is greatly facilitated and pathologic conditions of the bladder can be demonstrated with ease. It should not supplant but supplement the usual ascending pyelography.—*T. Leucutia.*

Manevitch, A. E., and Froumkine, A. P. L'influence de la gestation sur l'état des voies urinaires étudiée par l'urosélectan et l'abrodril. (Influence of gestation on the status of the urinary paths as studied by uroselectan and abrodil.) *Presse méd.*, March 12, 1932, *40*, 396–398.

The question of pyelitis in pregnancy was studied previously by various methods. Thus the Schmidt brothers used pyelo- and ureteroscopy, Prutz, Jolly and Hirsch postmortem examinations, Beaufond, Vaudescal, and Pocher and Dozsa retrograde pyelography, etc. All investigators arrived at the conclusion that the primary cause lay in the dilatation of the ureters and kidney pelvis which is produced by the pressure of the enlarged uterus.

The authors studied the problem by direct pyelography after intravenous injection of uroselectan and abrodil. They found that in all cases of pregnancy dilatation of the kidney pelvis and ureters with adynamia of the peristaltic movements and slowing up of the evacuation follows from the fourth month on, and that the anatomico-physiologic changes are more marked on the right side than on the left. This establishes very favorable conditions for the penetration of the bacteria, resulting in all kinds of secondary infections.—*T. Leucutia.*

Chevassu, Maurice, and Moret, François. Le moulage radiographique des cavités du rein et de l'uretère au moyen de l'uretéropyélographie rétrograde, d'après 1,250 cas. (Roentgenographic molds of the cavities of the kidney and of the ureter by means of retrograde uretero-pyelography in 1,250 cases.) *Bull. et mém. Soc. de radiol. méd. de France*, Feb., 1932, *20*, 57–67.

One of the authors, in 1928, described the method of retrograde uretero-pyelography applied under pressure, leading to veritable molding of the cavities examined. The method was

carried out in the usual way, except that the ureteral sounds were provided with stoppers which were tightly introduced into the ureteral orifices to prevent the backflow of the opaque substance during the injection. The material was injected very slowly until the patient complained of pain.

The method has now been used in 1,250 cases with very satisfactory results. Since the introduction of uroselectan which is considerably less painful than the previously used sodium iodide, the authors were able to even inject both kidneys simultaneously without untoward effect.

The value of the method is described for the following conditions: anomaly of the ureter and kidney, pyelonephritis, carcinoma of the kidney, polycystic kidneys, renal calculi, tuberculosis, perinephritic phlegmon, traumatism of the kidney, renal ptosis, hydronephrosis, ureteral calculi, pelvic obstruction of the ureter, etc.

The authors doubt that descending urography, which has been so actively advocated recently, will ever arrive at a stage of development where such instructive images could be obtained as with the above method.—*T. Leucutia.*

SKELETAL SYSTEM

Skossogorenko, G. F. Calcinosis interstitialis universalis. *J. Bone & Joint Surg.*, April, 1932, *14*, 339–345.

Calcinosis interstitialis universalis and arthritis nodosa are terms applied to the rare and peculiar disease involving the calcium metabolism, the etiology of which is not clear. Its treatment has not yet been evolved. Clinically this disease shows multiple deposits of calcium salts in the subcutaneous, periarticular, peritendinous, perimuscular, perinervous, perivascular, adipose or interstitial tissues. These deposits vary in size from a millet seed to a pigeon egg, and usually have the appearance of platelets, clots or crumb-like masses, with smooth but mostly uneven edges. Each individual case may vary in its distribution of the calcium deposits. Occasionally the latter present a symmetrical distribution.

As to the chemical nature of the deposits, some authors have called them carbonates, others, phosphates. All ages are subject to the disease. Repeated infection often aggravates the condition. In adults the location of the disease is more apt to be limited than in younger subjects, and its clinical course is usually benign. Some writers speak of the progressive and the regressive types.

The author reports one case in detail. No convincing information could be found in the literature regarding successful treatment. He discusses the various theories of its etiology. Since none of these hypotheses have been definitely verified, no outline of treatment can be given. The wide distribution of edema in his case seemed to have a great influence on the pathological changes of the disease. The pathological examination of the excised specimen from the edematous leg of his patient showed changes which he considered as the result of compression of the long-continued edema, which rendered the tissues unstable and passive to the deposit of calcium. Probably the disturbance in the calcium balance which was noted resulted from the atrophy of the osseous system under the influence of the compression of the edema, and the simultaneous disturbance of the function of the kidneys. His treatment consisted in introducing daily by mouth a solution of ammonium chloride combined, after an interval of one and one-half to two hours with the application to the extremity of Bier's hyperemia. This was based upon the fact that solution of ammonium chloride by mouth is apt to produce blood acidosis which in turn has its influence upon the osseous system by alkalinizing the calcium salts. This treatment resulted in a decrease in the size of the calcium nodules as determined by palpation. The patient felt greater ease in the affected joints.—*R. S. Bromer.*

Kaplan, Emanuel B. A case of multiple spontaneous fractures of unknown origin. *J. Bone & Joint Surg.*, April, 1932, *14*, 412–415.

While multiple spontaneous fractures are observed not infrequently in children, they are also seen in adults, although less often. Kaplan states that the case, he here reports, presents certain peculiarities which make the differential diagnosis difficult. The patient was a white female, about thirty-five years old, with complaints of weakness and fractures of the fingers of the hands. The fractures occurred in the usual course of her work of manicuring. A complete examination of the skeleton revealed fractures of the shafts of all the metatarsals and old fractures of the proximal phalanges of the second and fourth toes; old fractures of the right tibia and left fibula; united fractures

of the second and third metacarpals, right hand and a united fracture of the proximal phalanx, left hand with excess and irregular new bone production; old united fractures of the ulnae.

Idiopathic fragilitas ossium, osteomalacia, Schulze's marble bone disease, osteoporosis, rickets and neurotrophic, parasitic and neoplastic pathological changes could be considered in the differential diagnosis. The history of the late appearance and the peculiar localization of the fractures, he says, rules against fragilitas ossium. The normal condition of the patient's pelvis and spine, the occurrence long after pregnancy and the roentgen appearance makes osteomalacia improbable. Marble bones presents an entirely different roentgenographic appearance. Repeated laboratory and clinical examinations did not disclose the presence of any chronic or parasitic infection. No signs of multiple neoplasms nor of neurotrophic disease were found. Kaplan does not offer a diagnosis.—*R. S. Bromer.*

Compere, Edward L., Streptococcus viridans osteomyelitis. *J. Bone & Joint Surg.*, April, 1932, *14*, 244–258.

Compere reviews and discusses the etiology of osteitis that is characterized by a fibroblast and giant-cell proliferation with bone destruction and new bone formation. He reports a case in which a strain of green-producing streptococcus grew in cultures of a lesion in the neck of the astragalus, which presented a microscopic picture similar to that of localized osteitis fibrosa without cyst formation. Clinically and bacteriologically it was a low grade pyogenic infection and he classes it as *Streptococcus viridans* osteomyelitis. He also reports a second case, which was clinically and pathologically similar to the first, except for bone proliferation, but in which cultures were negative. He suggests that trauma may be a factor in localizing the infection, but also expresses the opinion that reaction to trauma and hemorrhage could not alone account for the cortical absorption and the extensive new bone formation which was noted in his second case.

He states that it is most probable that the reason for the dearth of information concerning the incidence of *Streptococcus viridans* infections in bones is due, not so much to the rareness of the disease as to the failure of physicians to apply the technique elaborated for the investigation of streptococcus infections of the soft parts, to infections of bone. Using the technique which he employed in the two cases here reported (first employed by Rosenow for the the isolation of such organisms), Phemister, Brunschwig and Day succeeded in culturing *Streptococcus viridans* in two cases of Kienböck's malacia and one each of Köhler's disease, Legg-Perthes-Calvé's disease, and osteitis deformans. He suggests that the culture of these organisms in his first case, combined with the fact that Phemister and his coworkers have isolated *Streptococcus viridans* in culture from the lining wall of 4 cases of solitary bone cyst, adds an etiological link to the evidence that the two pathological conditions, namely, the so-called brown tumors of bone or giant cell tumors and bone cysts, may perhaps be different stages of the same process. While the lesion in neither of his two cases is typically that of the true benign giant cell tumor, the microscopic picture is similar to that seen in lesions classified in the osteitis fibrosa group.—*R. S. Bromer.*

Capener, Norman, and Pierce, Kenneth C. Pathological fractures in osteomyelitis. *J. Bone & Joint Surg.*, July, 1932, *14*, 501–510.

This paper is based upon a study of 1,068 cases of osteomyelitis. The authors were stimulated to make this study as they had found an extreme paucity of references to fractures in osteomyelitis in the literature. They desired especially to investigate the necessary precautions for prevention of these fractures. Delayed recognition of the disease and inadequate treatment in the early, acute stage are important factors in their occurrence. These both may be responsible for massive diaphyseal sequestration. They state that where there is sequestration involving the whole circumference of a long bone, the condition is essentially one of fracture, although none of the classical signs of fracture may be present because of the development of a supporting involucrum. Thus pathological fracture is a complication of the chronic stage of osteomyelitis, except in certain cases of epiphyseal separation due to an extensive acute metaphysitis.

Secondary factors are: (*a*) excessively large diaphyseal separation and (*b*) the formation of an involucrum that is inadequate to stand the normal stress brought to bear upon the limb. In addition, fracture is facilitated by imperfect immobilization and support of the diseased bone, and is therefore more commonly found in the single bones, the humerus and the femur,

than in those that have a companion bone for support.

This study revealed that pathological fractures in cases of osteomyelitis of the shafts of the long bones occurred in 1.66 per cent of a total of 1,068 cases. Osteomyelitis was responsible for 33 per cent of all pathological fractures in the long bones. They recommend that every case with massive sequestration should be regarded as a fracture before abnormal mobility or deformity is evident. A deep gutter rather than a shallow saucer is a safer mechanical means of dealing with central bone abscesses. In the removal of sequestra the involucrum should be conserved. Careful attention should be paid to the proper provision of splints or other support during convalescence.—*R. S. Bromer.*

King, Don. Osteochondritis dissecans; a clinical study of twenty-four cases. *J Bone & Joint Surg.*, July, 1932, *14*, 535–544.

King's study is based upon 24 cases of osteochondritis dissecans which from the standpoint of clinical history fell into three fairly well-defined groups. In one group were the very painful, swollen, tender joints, locked in 15 to 45 degrees of flexion. The appearance suggested traumatic injury. The trouble began very suddenly a few days previous, subsequent to a twist or other minor injury There was usually no history of previous disability. Roentgen examination revealed an osteochondritic focus of the medial femoral condyle, with two or three loose bodies in the joint.

The second group included cases which were asymptomatic. It occasionally happened that a roentgenogram of the supposedly normal knee, taken for comparison, revealed a definite osteochondritic focus, without free bodies in the joints. The body or "mouse" was lying quietly in its bed on the medial femoral condyle. These patients had "slumbering osteochondritis dissecans."

The largest number of cases was in the third group. In this group there was a definite history of trauma in a few cases. The story was that of a troublesome knee joint during two or three years. The complaint was a feeling of soreness, or definite pain on weight-bearing, associated with swelling. "Giving way" and stiffness were also common. These symptoms were sometimes continuous but more often intermittent, and were often associated with recurrent sudden "locking" of the joint on arising from a sitting or squatting position. Five of this last group felt a loose body in the joint.

In only one case did history and clinical examination lead to a suspicion of osteochondritis dissecans, all of the rest being diagnosed by roentgen examination. The three most usual clinical diagnoses were torn cartilage, tuberculosis, and loose body.

In the roentgenogram of the knee joint the process was almost always found on the postero-internal aspect of the medial femoral condyle on the articular surface. The entire focus appeared as a well-localized, almond-shaped area of lessened density, within which was a small sclerotic mass. Occasionally in the condyle at the edge of the focus there was a cystic area resembling a series of signet rings of different sizes, opening into the focus bed. The articular cartilage over the focus had a shredded appearance. Small portions, or rarely the entire sclerotic mass, appeared free in the joint. Old cases coming under observation for the first time usually had several loose bodies in the joint associated with arthritis. Occasionally in all these cases the original osteochondritic process was healed to such an extent that it could easily have been missed, all attention being concentrated on the arthritic process and the loose bodies. In the 4 elbow cases, the osteochondritic focus was found in the capitellum, with an irregularity and broadening of the radial head and in old cases with an increased length of the coronoid process and a thickening of the superior olecranon surface. Radical operation gave a good result in 88 per cent of cases. Slumbering osteochondritis dissecans should be treated conservatively without operation, as spontaneous healing has been demonstrated in these cases. Long-standing cases with many free bodies and severe arthritis may not be cured by operation, because many of the subjective symptoms are due to the accompanying arthritis.—*R. S. Bromer.*

Jaffe, Henry L., and Mayer, Leo. An osteoblastic osteoid tissue-forming tumor of a metacarpal bone. *Arch. Surg.*, April, 1932, *24*, 550–564.

Benign tumors of the short tubular bones of the hands and feet are relatively frequent; malignant tumors occur rarely. The authors describe a tumor of a metacarpal bone that began in a girl twelve years of age. The tumor was of slow growth. A biopsy showed osteoid tissue and numerous osteoblasts. Two years

later the tumor began to grow rapidly. After growing rapidly for about six months, an encapsulated mass measuring 10 by 6.5 by 6 cm. was removed. There was almost complete destruction of the metacarpal bone. The peculiar feature of this osteoblastic tumor was its capacity to produce large amounts of osteoid tissue, much of which was free from calcium. The tumor had some features common to cartilaginous elements in numerous sections. It was especially characterized by homogeneity of the histologic picture, a lack of polymorphism of the cells and an absence of tumor giant cells.

There has been no recurrence one and a half years after operation and the patient has remained free of metastases for over four years after the original biopsy. The authors believe that the case is an example of the so-called "osteoid chondroma" of Virchow, which is an osteoid tissue-producing tumor, the prognosis of which is better than that of osteogenic sarcoma. It was thought that had extirpation of the metacarpal bone been delayed much longer, the tumor probably would have undergone biologic transformation and developed the malignant capacities of true osteogenic sarcoma.

The case is reported in considerable detail with numerous illustrations showing the hand before and after operation, roentgenograms of the tumor at various stages in its growth, and many photomicrographs showing the histologic nature of the lesion.—*Karl Kornblum.*

Cohn, Bernard N. E. Congenital bilateral radio-ulnar synostosis. *J. Bone & Joint Surg.*, April, 1932, *14*, 404–405.

Radio-ulnar synostosis, or "congenital pronation" is a rare developmental anomaly involving the bones of the forearm. It consists of bony fusion of the proximal ends of the radius and ulna which are otherwise normal. This abnormality prevents normal rotation of the forearm, and occurs more frequently in males and is bilateral in about 50 per cent of cases. There is some evidence of a hereditary tendency. Other bony defects may or may not be present. Cohn's case is bilateral, occurring in a male, with no history of the same abnormality in other members of his family.

Roentgenographic examination of both elbows revealed a solid bony union between the proximal ends of the radius and ulna for a distance of 5.5 cm. The heads of the radii were present but were displaced somewhat anteriorly, thus accounting for the limitation of flexion on clinical examination. The humeri were normal.

The case history contains no mention of treatment, but is illustrated by roentgenograms.—*R. S. Bromer.*

Fahlstrom, Stanley. Radio-ulnar synostosis; historical review and case report. *J. Bone & Joint Surg.*, April, 1932, *14*, 395–403.

In radio-ulnar synostosis, generally thought to be congenital in origin, the upper ends of the radius and ulna are always involved and the lower ends are free. Supination is greatly impaired and the hand is held in a position of constant pronation. The condition is painless, is compatible with normal existence and offers poor promise from surgical intervention. A strong familial tendency has been noted and it occurs bilaterally in half the cases.

Two types are known to occur. In the first—true radio-ulnar synostosis—the radius and ulna are smoothly fused at their proximal borders for a variable distance, usually 2 cm. In the second form there is a radio-ulnar synostosis with congenital dislocation of the head of the radius. There is also an acquired form which results from trauma such as fracture or gunshot wound.

Kaplan gives a long and complete historical review with an extensive bibliography, containing 134 references. His case is illustrated by roentgenograms, showing the fusion of the radius and ulna.—*R. S. Bromer.*

Watson, William L. Fractures of the lower radial epiphysis. *Arch. Surg.*, March, 1932, *24*, 492–504.

The lesion dealt with in this article is one in which there is a solution of continuity in the radius at its lower extremity, and all, or at least part, of the line of separation passes through the cartilaginous plate of the epiphysis. This should be called a fracture instead of a separation or dislocation.

The anatomy of the part is discussed. Attention is called to the fact that nearly the entire blood supply of the epiphysis comes from the overlying periosteal network of arteries. The blood supply of the epiphysis is therefore independent of the diaphysis which accounts for the comparatively infrequent occurrence of necrosis in traumatic separation of the epiphysis. The epiphysis toward which the nutrient artery points usually unites to the shaft first, and con-

sequently the greater longitudinal growth is produced by the opposite epiphysis. The lower radial and ulnar epiphyses unite later than the upper ones do, and so produce the greater longitudinal growth. The age at which epiphyseal ossification takes place in the radius and ulna has been variously reported. The average is eighteen years for the head of the radius, from sixteen to seventeen years for the head of the ulna, and nineteen years for both distal epiphyses.

Regarding incidence, fracture of the lower radial epiphysis is the most common of all the epiphyseal fractures. The majority of cases are seen in the second decade of life. The injury is relatively uncommon after eighteen years of age. Most of the patients are of the male sex. The epiphysis is relatively more resistant to trauma than the lower end of the radius in adult life.

These fractures are nearly always due to indirect violence. A back thrust from a fall on the outstretched hand or from hyperextension is the usual cause, or, as Cotton said, the causes are the same as those which produce a Colles' type of fracture in the adult. The displacement of the lower radial epiphysis is usually upward and backward. Impaction is rare. Roentgenograms of the normal as well as the injured wrist should be taken in the anteroposterior and lateral directions. It is well to note that epiphyseal fractures without displacement often cannot be picked up by roentgenography and are commonly diagnosed as "sprains." Unfortunately, these undiagnosed fractures are prone to result in arrest of growth.

Treatment consists of reduction and immobilization for from eighteen to twenty days. There is little tendency for the deformity to recur after complete reduction. The union is more rapid than in Colles' fractures in adults. In complicated cases, an open operation may be necessary. If there is subsequent cessation of growth of the radius after epiphyseal injury, it may be necessary to remove a section of the shaft of the ulna to overcome the resulting deformity of the wrist or, conjugal chondrectomy, that is, excision of the conjugal cartilage of the ulna, may be performed to produce arrest of growth of the ulna.

Various complications may occur. The most important is a disturbance in growth activity. The severity of the resulting deformity is dependent on the degree of injury to the epiphyseal cartilage and its blood supply. Minor injuries to these structures cause retardation of longitudinal growth and more severe injuries produce a premature ossification of the epiphysis to the diaphysis, the resulting degree of wrist deformity being greater the younger the patient is at the time of the accident.

Regarding prognosis, no cases of non-union have been reported, and, in the uncomplicated cases, union takes place in the second or third week. The resulting wrist function is good.

The literature contains very few references to the treatment for premature ossification of the lower radial epiphysis. The author reports two cases of this kind, in one of which an operation was performed and in the other no operation was done.

Conjugal chondrectomy is the operation recommended by the author.—*Karl Kornblum.*

Lang, F. J. Osteo-arthritis deformans contrasted with osteo-arthritis deformans juvenilis. *J. Bone & Joint Surg.*, July, 1932, *14*, 563–573.

Lang bases his study of the adult and juvenile types of osteoarthritis deformans upon the anatomical and histological changes present in the two types of the disease. Osteoarthritis deformans is a chronic non-infectious and proliferative inflammation that leads to a deformity of the joint structure. Marginal exostoses are characteristic and constitute the decisive feature for the diagnosis of the condition. These marginal exostoses are not ossified excrescences, or periosteal or perichondral proliferations, or osteophytes, or periosteal lippings; they are bone formations, which arising from the subchondral marrow tissue grow out into the joint cartilage. They possess a laminated structure, are united to the spongiosa and are usually covered with cartilage. The joint cartilage shows alterations in consistency associated with a splitting of the ground substance which disturb and damage the elasticity of the cartilage. As a sequel of vascularization and ossification of the cartilage its deeper portions are undermined. The portions thus separated by undermining are often found to lie deep within the spongiosa and, in this position, they mark the site of the original boundary between bone and cartilage. Despite the changes in the surface of the cartilage, vascularization and ossification of the basal layer cartilage rarely take place. The cause for this is either that the calcification zone of the joint cartilage is very broad, or the subchondral bone is very compact. The

subchondral bone is thus protected against functional and mechanical damage in spite of the loss of elasticity in the overlying cartilage. So it is obvious that arthritis deformans is dependent for its development on a combination of functional and anatomical circumstances.

Lang describes the histological changes in great detail and, after due consideration of his findings, concludes that the distinction between the atrophic and the hypertrophic or between the degenerative and the hyperplastic types of arthritis deformans is not necessary. The varieties are but gradations of a process that is uniform as regards its origin.

A distinction between the chondral and the osseous forms of arthritis deformans is also unnecessary. In the final analysis, it is the damage to the cartilage with its resultant loss of elasticity that is responsible for the origin of the disease. Under all conditions the character of arthritis deformans is a chronic, proliferative, non-infectious inflammation of the joint and therefore the only justifiable designation of this process is "arthritis." "Arthrosis" is a term which should not be used as it implies a degenerative process.

Regarding the causes of the condition, Lang admits that a direct relationship exists between arthritic change and certain systemic diseases. The functional theory of Pommer offers a satisfactory explanation in that it presupposes that the joint cartilage, through its elasticity, protects the subchondral bone and its marrow from the irregular, localized effects of impacts, jarrings, and pressures arising from normal function. Following damage to the joint cartilage, with subsequent loss of its elasticity, the mechanical effects of normal joint function become more or less localized and are transmitted unmodified to the joint structure resulting in a reactive vascularization and ossification of the cartilage. The recognition of the functional and mechanical importance of joint cartilage as the protective covering of the subchondral bone demands that the mechanical and functional damage to the joint cartilage be adjudged the most important factor, not only in the pathogenesis, but also as the etiological factor of arthritis deformans. In Lang's study of juvenile joints he was able to substantiate the theory that arthritis deformans is already initiated in the early years of life and, therefore, the disease has to be considered as a consequence of trauma carried over from childhood and adolescence. In his investigation of the juvenile form of arthritis deformans in cases of Legg-Perthes-Calvé's disease of the hip joint and Köhler's disease of the first and second metatarsal bones and other so-called aseptic necroses, he found the characteristic diagnostic features of arthritis deformans, namely, changes in the joint cartilage, vascularization and ossification of the cartilage, and marginal exostoses. He found it evident that functional traumata are the determining factors for the origin of juvenile arthritis deformans.

He concludes that there are no fundamental differences between arthritis deformans of the adult and juvenile arthritis deformans. Both types originate after damage to the articular and joint cartilage with subsequent loss of its elasticity. This loss of elasticity removes the protection that the normal cartilage affords to the subchondral bone against functional and mechanical influences. The decisive factor for the progressive course of both types is the action of the functional requirements which, acting as a source of constant irritation, form the basis for the progressive character of the disease.—*R. S. Bromer.*

VOLUME XXX SEPTEMBER, 1933 NUMBER 3

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

The AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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